INFLUENCE OF TWO ATTENTIONAL STRATEGIES ON PERFORMANCE, QUIET EYE DURATION, AND COMPETITIVE ANXIETY IN AN UNDERHAND DART TOSSING TASK

By

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The general purpose of this investigation was to examine the influence of two different attentional strategies on visual attention and performance in a task under a competition condition as well as a non-competition condition. Specifically, the intent was to (1) investigate the influence of an external focus strategy and an internal focus strategy on quiet eye duration (QED, Vickers 1996a), which was defined as final fixation time on the target with onset prior to the final throw, as well as performance of an underhand dart tossing task, and (2) investigate the influence of competitive anxiety on quiet eye duration as well as performance.

To fulfill these purposes, two separate experiments were conducted. In Experiment 1, 42 university male students were randomly assigned to one of three strategy groups (external focus strategy, internal focus strategy, or control) and then they performed 64 trials at the task. In Experiment 2, the three groups performed 32 trials

under either a competition condition or a non-competition condition. Participants who performed in the competition condition competed for a monetary reward. Performance was assessed by distance deviation from the center target on each toss by calculating mean radial error (MRE), subject-centroid radial error (SRE), and bivariate variable error (BVE) scores. QED, which refers to the portion of the final eye fixation from onset to the target to the first observable movement of the hands for the shooting action, was measured each toss in Experiments 1 and 2. The Competitive State Anxiety Inventory – 2 (CSAI–2) was administered immediately prior to Experiment 1 and immediately prior to Experiment 2 to measure state anxiety level.

In Experiment 1, performance of the three groups improved over trials in terms of accuracy (MRE), consistency (SRE), and variability (BVE). However, there was no difference among the groups. The external focus strategy group demonstrated a longer QED than the internal focus and the control groups. However, there was no QED difference between the internal focus group and the control group.

In Experiment 2, the external and internal focus strategy groups demonstrated better dart performance in terms of less variability than the non-strategy (control) group. The external focus strategy group demonstrated a significantly longer QED than the internal focus strategy and control groups in the non-competition condition, and the difference between the external focus strategy group and the other groups was even greater in the competition condition. However, there was no performance difference between the external focus strategy group and the internal focus strategy group. Participants performing the task under the competition condition demonstrated an increase

in anxiety level. However, those who performed the task under the non-competition condition demonstrated a decrease in anxiety level.

Generally, it appears that an increase in QED associated with an external focus strategy does not lead to enhanced performance in an underhand dart tossing task, contrary to expectations.

CHAPTER 1
INTRODUCTION

How to best enhance the learning and performance of skills has been a major research topic among scientists concerned with sport. Researchers in sport psychology have often investigated this topic with an information processing paradigm, in which a person is viewed as a processor of information with limited capacity. This paradigm is associated with understanding encoding, decoding, storage, retrieval, and transformation of information (Schmidt & Lee, 1999). Many sport skills involve the refined execution of complex body movements, which are assumed to require a great amount of processing of situational and personal information in order to master them. For example, self-paced motor skills, such as dart throwing, pistol shooting, golf putting, archery, and billiards, require the programming of extremely precise aiming movements at the neural level (Vickers, 1996a). While performing such skills, even a very small error or slight distraction can make a huge difference in the outcome of performance.

With regard to these considerations, scientists in sport psychology have recognized visual information to be a very important factor for the attainment of proficiency (Gavrisky, 1969; Kluka, 1999). Especially, issues related to visual attention, such as location of a performer's eye fixation and the duration of eye fixation have been of major interest. In other words, selective visual attention while performing motor skills in various sport situations has been assumed to be very crucial for successful performance. Another factor assumed to be important is coping with anxiety. Much

research has been conducted to investigate the interactive effects of anxiety components (e.g., cognitive and somatic anxiety) on performance. Usually, this research has typically been concerned with the global relationship between anxiety/arousal and performance (Jones, 1990; Jones & Hardy, 1990). Relatively few researchers have incorporated visual attention and competitive anxiety, which are two influential and crucial factors related to sport performance, together in their studies. More needs to be known about the relationship between the two factors with regard to performance.

Furthermore, in this context, are questions concerning performance enhancement, the influence of an attentional orientation strategy on visual attention, and, in turn, performance under competitive stress situations. Teaching a novice an appropriate attentional strategy should influence attentional behaviors as well as regulate cognitive processing, thus resulting in enhanced performance. Although scholars in sport have studied issues related to cognitive strategies (e.g., Ko & Singer, 1998; Lidor, 1991; Lidor, Tennant, & Singer, 1996; Singer, 1988; Singer & Lidor, 1993), they have not typically addressed the relationships among performance, visual attentional strategy (external and internal), and competitive anxiety. Therefore, the purpose of this study was to design a comprehensive investigation of the influence of two different attentional cognitive strategies (external and internal) and competitive anxiety on visual attention as well as on the learning and performance of a self-paced motor skill.

Visual Attention

A substantial amount of research and reviews (e.g., Abernethy, 1993, 1996; Brogan, 1988; Folk & Remington, 1996; Just & Carpenter, 1976a, 1976b, 1980; Neumann, 1990; Posner, 1980; Ripoll, Kerlirzin, Stein, & Reine, 1995; Vickers, 1996a,

b; Viviani, 1990; Williams, Davids, & Williams, 1998; Wright & Ward, 1998; Yantis, 1996) in sport as well as in other areas of interest to sport psychologists has been oriented toward determining the role of visual cues and attention in acquiring and realizing motor skills. Results from early research (e.g., Just & Carpenter, 1976a, b) indicated that internal information processing could be identified by external eye movements, thereby supporting the notion that higher-order cognitive processes control the location and duration of ocular fixations. This notion is called "eye-mind-connection" (Frehlich, 1997). Although several researchers (e.g., Klein, 1994; Theeuwes, 1994) have criticized the notion by demonstrating that the line of sight does not always coincide with the direction of attention, the concept of "eye-mind connection" has been a basic assumption in much research related to visual attention, eye movements, and motor skill.

Magill (1998) and Williams, Davids, and Williams (1999) suggested that, with caution and well-devised research designs, researchers can use certain eye movement patterns as an indicator of internal cognitive processing. For example, in open skill sport situations such as tennis, soccer, volleyball, and boxing, researchers (e.g., Abernethy, Wood, & Parks, 1999; Ripoll, Kerlirzin, Stein, & Reine, 1995; Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996; Vickers & Adolphe, 1997, 1998; Williams, Davids, Burwitz, & Williams, 1994; Williams, Davids, & Williams, 1998) have observed expert-novice differences in the visual search of particular features in sport environment, thereby showing a certain degree of association between cognitive processing and specific patterns of eye movements. In general, results indicated that when compared with novices, experts tend to be faster and more accurate in recognizing relevant cue patterns, and excel in anticipating the actions of an opponent. They also make quicker and better

decisions with more efficient and effective eye movement patterns (Abernethy, Burgess-Limerick, & Parks, 1994; Singer, 1998).

In self-paced sport situations, such as foul shooting in basketball, golf-putting, shooting, and dart tossing, studies (e.g., Janelle, Hillman, Apparies, & Hatfield, 2000; Janelle, Hillman, Apparies, Murray, Meili, Fallon, & Hatfield, 2000; Ripoll, Bard, & Paillard, 1986; Ripoll, Papin, Guezennec, Verdy, & Philip, 1985; Vickers, 1992, 1996a, b; Vickers, Williams, Rodrigues, Hillis, & Coyne, 1999) also indicated differences in visual attention capabilities and characteristics between experts and novices. Overall, experts appear to orient more effectively to the target than non-experts. Highly-skilled experts demonstrate a more systematic and selective attentional focus. For example, in Vickers' study (1996b), while expert and near expert basketball athletes performed 10 accurate and 10 inaccurate free throws, their gaze behaviors were measured. Gaze behaviors include several types of gaze control, such as eye fixation, saccade, and tracking measures (Vickers, 1996b). Results indicated that expert players had a more efficient gaze behavior, recording lower frequencies and longer durations of eye fixation on critical locations in the targeting area. Furthermore, Vickers found that there was a consistent difference in quiet eye duration (QED) between expert and non-expert players in the preparatory stage to shooting.

Quiet Eye Duration in Aiming Tasks

In a series of studies (e.g., Vickers, 1992, 1996a, b), Vickers investigated eye movements (or what she has referred to as gaze behaviors) of expert and non-expert athletes with golf putting and basketball free-throw tasks. Among several eye movements recorded, she found that the QED of the expert was consistently

distinguished from that of the non-expert. QED was defined as the period of time from the last eye fixation on the target to the first observable movement of the hands in executing the action (Vickers, 1996a). Based on her results, Vickers suggested that the QED reveals how the performer processes visual information from a specific location prior to performing the task (Vickers, Williams, Rodrigues, Hillis, & Coyne, 2000). She contended that QED is a very critical period of cognitive programming required for successful aiming to a target, and has provided strong evidence in support of the eye-mind connection. Therefore, for aiming-type tasks (e.g., shooting, archery, and darts), an optimal QED probably exists for best performance. Reduction in it more than likely results in poorer performance.

In self-paced sports, the environment is stable and there is usually sufficient time to prepare oneself to perform. In this situation, it had been suggested that the visual and motor systems are tightly integrated, and that eye fixation location and duration is highly associated with degrees of success (Abrams, Meyer, & Kornblum, 1990; Frehlich, 1997; Vickers, 1996a, b). With this assumption, such researchers as Abrams et al. (1990), Frehlich (1997), Ko and Singer (1999), and Vickers (1992, 1996a, b) have speculated that foveal vision is directly associated with visual attention in self-paced skill situations.

Attentional Cognitive Strategy for Achieving in Aiming Tasks

Research comparing novices and experts in sport has shown that many systematic and strategical differences exist between them (Abernethy, 1996; Abernethy, Burgess-Limerick, & Parks, 1994). One such strategic difference used by skilled performers is their ability to direct attentional focus to appropriate sources of information, which is critical to performance. For example, in self-paced activities such as darts, archery, or

rifle shooting, researchers have demonstrated that experts usually focus their attention externally on one most important environmental feature (usually a target) associated with the task and ignore irrelevant sources of information (Nideffer & Bond, 1989). Thus, it is believed that they use a kind of "external focus" strategy. When an external strategy is used, thought is directed toward the goal of the action and perhaps aspects of the movement prior to execution, but during the action, attention is usually focused on a most relevant target cue.

On the other hand, beginners are traditionally instructed to direct their attention inward and focus on what they are doing during execution (Gallwey, 1981). They are told to be aware of the movement of body parts to get the feel of the movement. Such an "internal focus" strategy is usually emphasized in order to understand how to gain control of important proprioceptive and kinematic mechanisms involved in the acquisition of movement skill (Feldenkrais, 1972). However, results from recent studies (e.g., Singer, Lidor, & Cauraugh, 1993, 1994) on beginners have demonstrated support for directing attention externally rather than internally during or prior to the execution stage. In other words, beginners can apparently adopt certain attentional cognitive strategies usually associated with experts, which in turn will enable them to learn certain sport skills faster. However, more evidence is required to substantiate this point.

Measuring direction of attention during the subtle moments immediately prior to movement execution is not easy. In the past, such measurements as reaction time (Christina & Rose, 1985), accuracy scores (Singer, DeFrancesco, & Randall, 1989; Singer & Suwanthada, 1986), and self-reports (Jackson, 1981) have been used. Another potential measurement which has been proposed in recent years is QED (Vickers, 1996a).

Since Vickers (1996b) has proposed the notion of QED, it has been investigated by relatively few researchers (e.g., Adolphe, Vickers, & Laplante, 1997; Frehlich, 1997; Ko & Singer, 1999). In a study by Adolphe et al. (1997), elite volleyball athletes participated in a 6-week visual attention training program which included video feedback of gaze behavior and on-court training to enhance ball detection, tracking, and forearm passing skills. Results showed improvement in performance and suggested the potential of training selective visual attention, including QED. An exploratory study by Ko and Singer (1999) involved the QED and the application of a cognitive strategy that might influence it. They investigated the effect of the Five-step Strategy (Singer, 1988) on visual attention (as measured by QED) to the target while participants learned an aiming task (underhand dart tossing). Results indicated that participants in the Five-step Strategy (FSS) group had longer QED as well as better performance. The FSS is a comprehensive global strategy that includes characteristics of both an external focus strategy and an internal focus strategy.

More research is needed to determine the effectiveness of appropriate attentional focus strategies in influencing QED, and in turn achievement in aiming-type tasks. Their role for such purposes served as a major reason for conducting my study. Specifically, an external focus (unawareness) strategy and an internal focus strategy (awareness) strategy will be compared in terms of effects on QED as well as on performance. Both have been studied previously with several motor tasks such as golf putting and ball tossing at a target. However, it is still unclear which strategy might influence visual attention more effectively and more particularly, the QED and subsequent performance. With the exception of the Ko and Singer study (1999), no other data are apparently available.

Vickers (1996a, b) and Frehlich (1997) have asserted that QED is a reliable index for internal cognitive processing. Vickers also proposed the location-suppression hypothesis (for more detail, see Vickers, 1996b), in which a fixation of a relatively long duration on the target is presumed to be necessary during the preparatory phase for movement execution in order to set the movement parameters, such as the location and distance to the target. Presumably, during the act, the expert looks away from the target (suppresses the orientation to the target). The location part of her hypothesis was supported by the results of Frehlich's research (1997). Ko and Singer (1999) suggested that if QED is a reliable index for internal cognitive processing and better proficiency as Vickers (1996b) and Frehlich (1997) asserted. Such information could be useful and desirable to determine how to help beginners direct their attention appropriately. This issue is one of the primary concerns in my investigation.

Consideration of Competitive Anxiety

Another important consideration when investigating visual attention and performance proficiency is competitive anxiety, and its potential influence on them. Because competition is an inevitable part of sport, the influence of competitive anxiety, arousal, and stress on performance has been a major research topic. From early work (e.g., Spielberger, 1966, 1972) on state/trait anxiety and later developments leading to multidimensional models of anxiety (e.g., Martens, 1974, 1975, 1977, 1987; Martens, Burton, Vealey, Bump, & Smith, 1990; Martens & Simon, 1976), to more recent proposals such as the cusp catastrophe hypothesis (e.g., Hardy, 1990, 1996; Hardy, Jones, & Gould, 1996; Hardy, Mullen, & Jones, 1996; Hardy, Parfitt, & Pates, 1994), many ideas have been advanced about the nature of competitive anxiety and its relationship to

sport performance. However, very few studies have been concerned with the relationship of competitive anxiety and visual attention. Especially, the investigation of QED and competitive anxiety is rare because the concept of QED is relatively new. Some exceptions are Janelle, Singer, and Williams' study (1999) and recent research by Vickers, Williams, Rodrigues, Hillis, and Coyne (2000). Vickers et al. (2000) tested 12 elite biathlon shooters performing 10 rifle shots under high and low anxiety conditions. Results showed that under the low anxiety condition, shooting accuracy was increased, as was QED. However, both accuracy and QED were decreased under the high anxiety condition. The researchers suggested that excessively high anxiety appeared to decrease QED as well as performance.

In general, visual attention and competitive anxiety are considered to be important factors influencing performance in sport yet the relationship between these two factors and motor skill performance has been rarely studied. Furthermore, investigations dealing with these variables in relation to cognitive strategies do not apparently exist. Typically, researchers have studied visual attention, cognitive strategies, and competitive anxiety independently. Therefore, my study was conducted to attempt to explain these relationships as individually learned and performed a self-paced aiming task, underhand dart tossing. The conceptual framework of the study is presented in Figure 1.

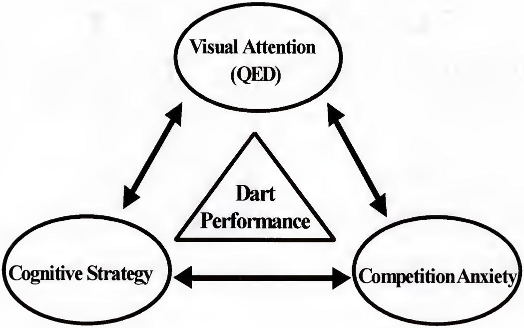

Figure 1.1. The framework of the study.

Statement of the Problem

The general purpose of the study was to investigate the influence and interaction of particular attentional strategies (external orientation vs. internal orientation) and competitive anxiety (cognitive and somatic) on visual attention and the learning and performing of an underhand dart tossing task. The first experiment was conducted to determine (1) whether the two strategies differentially influence visual attention to a target, as measured by quiet eye duration (QED), and (2) whether the strategies differentially influence the learning of the task. In the second experiment, an attempt was made to determine (1) whether an increase in competitive anxiety positively or negatively influences visual attention to a target, (2) whether an increase in competitive anxiety positively or negatively influences the performance of the task, and (3) the attentional strategy and competitive anxiety interaction with regard to performance. Measured were QED, anxiety components (cognitive anxiety, somatic anxiety, and self-confidence), as well as accuracy, consistency, and variability of dart performance.

Hypotheses

A series of hypotheses were tested. In Experiment 1, participants were assigned to one of three groups (external focus strategy, internal focus strategy, and control), and were asked to perform an underhand dart tossing task. In Experiment 2, the participants in each group (external strategy, internal strategy, and control) were divided and performed the same task either in a competition condition or in a non-competition condition. The first set of hypotheses was directed toward the manipulation of the attentional strategies and the effect of this manipulation on QED and dart performance.

These hypotheses were expected to be common to both Experiment 1 (practice/no competition condition) and Experiment 2 (retention/competition condition).

1. As to performance, it was hypothesized that participants in the two strategy (external focus and internal focus) groups would perform better, as indicated by lower mean radial error (MRE) scores, subject-centroid radial error (SRE) scores, and bivariate variable error (BVE) scores than those in the control group while they were learning the task. Accuracy is measured by MRE, consistency is measured by SRE, and variability is measured by BVE. The beneficial effects of both attentional strategies on performance were expected in the learning/non-competition session (Experiment 1) as well as in retention/competition session (Experiment 2). The prediction is based on previous findings (Ko & Singer, 1998; Lidor, 1991; Lidor, Tennant, & Singer, 1996; Radlo, Steinberg, Singer, Barba, & Melnikov, 1999; Singer & Lidor, 1993; Singer, Lidor, & Cauraugh, 1993, 1994). Although the two strategies have not been compared under competitive conditions, it was believed that participants in the two strategy groups would perform more successfully that the control group (Nideffer, 1993; Nideffer & Sagal, 1998; Radlo et al., 1999; Rotella & Lerner, 1993).

2. The MRE, SRE, and BVE scores of the external focus strategy group were predicted to be superior to those of the internal focus strategy group. This prediction was at least partly supported by previous studies (e.g., Lidor, 1991; Radlo et al., 1999; Singer & Lidor, 1993; Singer et al., 1993, 1994). In addition, previous observations (Nideffer, 1993; Nideffer & Bonds, 1989) provided support for the notion that self-paced skills in contrast to externally paced skills require a narrow non-distractible external focus of attention toward very few relavent cues.

3. Participants in the external focus strategy group were expected to demonstrate a longer quiet eye duration than those in the internal focus strategy group and the control group. This assumption is derived from the notion of the eye-mind connection (Frehlich, 1997). Especially in aiming type skills, such as the dart tossing and shooting, foveal vision is tightly associated with visual attention (Abrams et al., 1990; Frehlich, 1997; Vickers, 1996b). Therefore, an appropriate attentional strategy (i.e., external focus strategy) may change the gaze behaviors of a performer and this change can be measured by increased QED. Findings from Ko and Singer's research (1999) provided support for this hypothesis. In their study, the participants who used the FSS, which emphasizes external focusing on a target prior to execution of a self-paced skill, showed a much longer QED than those who did not use the FSS.

The next set of hypotheses is directed toward the introduction of a competition condition and expected results on visual attention and performance in Experiment 2. Hypotheses about the interaction between two different manipulations (attentional strategy and competitive anxiety) on measures of performance and visual attention are also included.

1. Participants under the competition condition were hypothesized to demonstrate relatively higher anxiety (cognitive and somatic) scores, measured by the modified CSAI-2, than those participants under the non-competition condition. The CSAI-2 (Martens et al., 1990) has been used by many researchers (e.g., Hardy, 1996; Hardy, Parfitt, & Pates, 1994; Jones, 1995; Jones & Swain, 1992; Orbach, 1998) as an appropriate and reliable state anxiety measurement tool in competitive sport contexts. In addition to a competition condition created in the present experiment, monetary incentive will be given

to stimulate anxiety/arousal. According to previous results from Fowler, Fisher, and Tranel (1982), Radlo (1997), and Tranel, Fisher, and Fowler (1982), a monetary incentive generates higher anxiety/arousal.

2. Groups performing under the competition condition were expected to demonstrate better dart performance (less MRE, SRE and BVE scores) than those under the non-competition condition. This belief is based on the cusp catastrophe model (Hardy, 1996), which describes the interactive effects of cognitive anxiety and physiological arousal/somatic anxiety. According to the model, increments in physiological arousal/somatic anxiety will positively influence performance until a certain optimal level, when cognitive anxiety is high. However, a further increase of physiological arousal/somatic anxiety may cause a sudden drop in performance. Therefore, the induced higher level of anxiety (which should not be too high but moderately higher than the anxiety recorded in the non-competitive groups) is expected to be a positive influence on performance.

3. Participants in the competition condition were expected to demonstrate a longer quiet duration than those in the non-competition condition. According to processing efficiency theory (Eysenck & Calvo, 1992), although an increased level of anxiety (especially cognitive anxiety) may reduce attentional resources available for performing a task, it may also motivate increased cognitive and physiological efforts to perform it. Furthermore, the dart task only requires attention to the target. Increased effort may be indicated by changes in visual attention behaviors such as the QED. Therefore, increased anxiety in the competition groups should extend the duration of the quiet eye period. In the other words, a more ideal (longer) QED should occur.

4. The strategy groups should demonstrate different anxiety profiles (cognitive anxiety, somatic anxiety, confidence, and perceived direction of anxiety symptoms), as compared to those in the non-strategy groups. The effects of attentional strategies on anxiety components (e.g., somatic and cognitive anxiety) and their interaction have not yet been studied thoroughly under competitive conditions. However, research and reviews (Chen & Singer, 1992; Ko & Singer, 1998, 1999; Lidor, 1999; Nideffer, 1976, 1993; Radlo et al., 1999; Singer, 1988; Singer, Cauraugh, Tennant, Murphey, Chen, & Lidor, 1991) have suggested that appropriate cognitive strategies should help in optimizing performers' arousal/anxiety level as well as internal cognitive processing, thereby resulting in a beneficial influence on performance.

Definition of Terms

To understand and standardize some of the terminology used in the study, the following terms are defined:

Arousal is defined as a general physiological and psychological activation that varies on a continuum from deep sleep (i.e., coma) to intense excitement (i.e., frenzy) (Gould & Krane, 1992; Weinberg, 1989).

Attentional strategy, typically internally- or externally-oriented, refers to direction, location, and orientation of attention immediately prior to and possibly during the execution of a motor skill.

Bivariate variable error (BVE) refers to intra-subject variability for two-dimensional error (Hancock, Butler, & Fischman, 1995). This score measures the inconsistency of responses, and is the 2D analog to variable error (VE).

Cognitive strategy refers to a sequence of higher-order mental procedures that influence information processing and self-regulation positively in order to optimize achievement outcomes (Chen & Singer, 1992).

Cusp catastrophe model is a three dimensional model that describes how one dependent variable (e.g., performance) can demonstrate both continuous and discontinuous changes as a result of continuous changes in two other independent variables (e.g., cognitive anxiety and somatic anxiety or physiological arousal) (Hardy, 1996).

Eye-mind connection refers to the belief that "eye movements can at the very least be considered as tags or experimentally accessible quantities that scientists can observe to understand underlying processes of cognition" (Viviani, 1990, p. 354). Stronger views of the eye-mind connection have assumed that eye movements are reflective of high-order cognitive processing (Frehlich, 1997).

Fixations occur when the individual's eyes pause at a specific location such that information is stabilized on the high-acuity area of the retina, the fovea (Vickers, 1992). Consistent with previous research (e.g., Vickers, 1996a, b), fixations were recorded when the participant's gaze was fixed on a location for 100 ms or more (3 or more video frames).

Fixation location refers to the areas in the display in which the eye fixates during preparation for and completion of a task (Williams, Davids, Burwitz, & Williams, 1994).

Quiet eye duration (QED) is defined as “the portion of the final eye fixation from onset to the target to the first observable movement of the hands into the shooting action” (Vickers, 1996b, p. 348).

Mean radial error (MRE) is a two-dimensional error score of overall accuracy in performance (Hancock, Butler, & Fischman, 1995). This score, which is the 2D analog to absolute error (AE), indicates the degree to which a participant's tosses deviate from the desired target on the average.

Self-paced skill refers to a motor skill in which a performer begins to execute when ready, has enough time to prepare, and has a stable and predictable (Schmidt & Lee, 1999; Singer, 2000).

Stress is characterized by a combination of stimuli or a situation that is perceived as threatening and which causes anxiety and/or arousal (Hackfort & Schwenkmezger, 1993).

Selective attention refers to "the process of selecting part of simultaneous sources of information by enhancing aspects of some stimuli and suppressing information from others" (Theeuwes, 1994, p. 94).

Self-confidence refers to the belief one has in being able to execute a particular behavior successfully (e.g., a sport act or event) (Bandura, 1986).

Somatic anxiety refers to perceptions of physiological arousal such as shakiness, sweating, increased heart rate, rapid respiration, and "butterflies in the stomach" (Martens, Vealey, & Burton, 1990).

Subject-centroid radial error (SRE) indicates information about the magnitude of movement bias over multiple trials from a single participant (Hancock et al., 1995). This measure is appropriate for answering questions about where, on the average, a participant's responses tend to be with respect to the center of the target. SRE is considered to be the 2D analog of absolute constant error (ACE).

Visual attention refers to the process by which individuals select information gathered by visual mechanisms to provide the basis for responding to particular stimuli (Theeuwes, 1994).

Visual search is the "the manner in which individuals move their eyes to take in available visual information while preparing and executing a movement or engaging in a decision-making process" (Vickers, 1996b, p. 342).

Assumptions

For the purpose of this investigation, the following assumptions were made:

1. The central dogma that the line of sight coincides with the direction of attention (Viviani, 1990) would at least be partially true, and therefore, visual orientation to a target would be reflective of the participant's actual allocation of attention.

2. The testing situation possesses a high degree of ecological validity, because participants will be required to complete a real-world task, dart throwing, with a regulation dart. In addition, competition for a reward (i.e., money) is similar to what could happen in normal dart game competition. The inclusion of this condition in the study should elevate anxiety level, thereby creating more realistic conditions for studying the variables of interest.

3. Participants in the external and internal strategy groups will use the strategies appropriately to prepare for and to execute each dart throw. To assure the usage of the particular strategy, participants will be asked to name the strategy between trials. A post-experiment questionnaire (5 point Likert scale; see Appendix E) was given to validate their usage. The data of those who recorded a score less than 4 (indicating that they did not use the instructed strategy often or all the time) were discarded. Participants were

expected to understand and follow the directions given prior to testing and before each dart throw.

4. A modified CSAI-2 was an appropriate and reliable instrument for measuring cognitive anxiety, somatic anxiety, and self-confidence. Martens and his colleagues (1990) reported evidence indicating the reliability and validity of CSAI-2 as an appropriate state anxiety measurement tool in competitive sport contexts. The modified CSAI-2 has been used by several researchers (e.g., Hardy, 1996; Hardy, Parfitt, & Pates, 1994; Jones, 1995; Jones & Swain, 1992; Orbach, 1998) to measure the direction dimension (perceived as beneficial or as detrimental) of competitive state anxiety as well as the intensity dimension.

5. Hypotheses related to the cusp catastrophe model could be tested by using somatic anxiety instead of physiological arousal. Hardy (1996) preferred physiological arousal rather than somatic anxiety as one of independent variables in the model. However, he also suggested that at least a weaker test of the model could be performed by using cognitive anxiety and somatic anxiety (in place of physiological arousal). Research (e.g., Hardy & Whitehead, 1984; Ussher & Hardy, 1986) indicated that the two variables (somatic anxiety and physiological arousal) are highly correlated.

6. The scores that are used in this study (MRE, SRE, and BVE,) are appropriate to examine accuracy, consistency, and variability in dart performance with a two-dimensional target (Hancock, Butler, & Fischman, 1995).

7. Participants were unaware of the hypotheses tested. In this experiment, they had the opportunity to receive either a monetary incentive or a cognitive strategy, or both. To avoid information about these manipulations and their predicted outcomes being

passed on from previously tested dart throwers to future participants, debriefing was done after all dart throwers' data were collected.

Limitations

Given the technological factors associated with this study, the following limitations would exist and should be acknowledged when interpreting the results.

1. The exact point of eye fixation was measured frame by frame with respect to the visual display. System accuracy is ±1° visual angle with precision of 1° in both vertical and horizontal fields. Therefore, very small eye movements, which are called "micro- or miniature movements", were ignored during eye fixation recordings. These small movements are usually observed when a participant is attempting to fixate on a stationary target. Because of their small amplitude, exact knowledge of their characteristics needs further clarification with more sensitive recording techniques (Carpenter, 1988).

2. The eye movement monitoring system collects data with special instrumentation (weighing approximately 700 g) that was mounted on the participant's head. This added weight may serve as an inconvenience for the participant, and may detract from the ecological validity of the dart situation. However, previous researchers using this instrumentation with other self-paced sport tasks have reported no significant reductions in performance, thus indicating that it may not be inherently intrusive (Vickers, 1992, 1996a, b; Frehlich, 1997; Ko & Singer, 1999).

3. To prevent development of their own strategies for a dart tossing task, participants in the treatment groups learned the attentional strategies (external and internal focus) first and then practiced the task. However, participants in the control

group might still have developed their own cognitive strategy to help their performance. An open-ended questionnaire assessing strategy use was administered at the end of the experiment to determine if such problems existed as well as to assure the use of correct strategy in the treatment groups.

4. Using underhand dart tossing (i.e., novel task) instead of normal overhand dart tossing may diminish the ecological validity of the testing situation. However, the participants in this study were novices anyway, and learning a self-paced novel skill was of the primary interest in this study. Thus, it should not be a problem with using an underhand dart tossing task in order to generalize the findings to other self-paced tasks with similar characteristics.

Significance of the Study

Investigating the relationships between visual attention and performance using sophisticated eye movement recording devices is becoming more popular among researchers. Studying eye fixation location and duration in a performer's visual search patterns could provide meaningful insight about his or her selective attention characteristics related to performance level (Abernethy, 1993). However, most studies have not involved competitive anxiety, which is assumed to be very influential on performance. Although some researchers have addressed changes in anxiety level and visual attention (measured by QED) in relation to performance, more investigations are needed for further clarification. In addition, designated cognitive strategies have not been investigated together with quiet eye duration and competitive anxiety. Since QED has been established as a reliable index to indicate visual attention toward the target in

aiming-type tasks, it would be useful to investigate the effects of attentional strategies and competitive anxiety on QED and performance.

One of the primary intentions in this study is to contribute to and expand the body of knowledge regarding the ability in competitive sports and other competitive activities to attend to and process the most relevant cue (or cues) and to perform more effectively with appropriate attentional strategies. Though an underhand dart tossing task was used in the study, the implications of the results were intended to be generalized, to a certain extent, to other competitive self-paced skill situations. The competitive situation that was relatively close to real dart competition (i.e., ecologically valid) in a laboratory setting.

A number of issues of theoretical and applicational importance were expected to be addressed in the investigation. First, a greater understanding of the eye-mind connection was provided by the data. In darts, which is a self-paced aiming-type task, it has been assumed that the visual and motor systems are very closely associated, and thus eye fixation location and duration are highly related to degree of success (Frehlich, 1997; Vickers, 1996a, b). Research (e.g., Abernethy, 1990, 1991a, b), which showed only marginal or no differences in visual search patterns between experts and non-experts, usually involved externally-paced motor tasks in laboratory situations. Using filmed (or video taped) opponents in the tests were also very common in these studies. Frehlich (1997) and Vickers (1996b) pointed out that studies in which filmed opponents have been used may decrease ecological validity. Researchers such as Bootsma (1992) and Davids, Hanford, and Williams (1994) also argued that any investigation conducted in an artificial setting limits the ability of an individual to access valuable information from the "real" environment.

Second, another important issue of interest in the study was to contribute to a better understanding of the relative effectiveness of attentional strategies (external versus internal focus) in enhancing the learning and performance of self-paced motor skills. Their influence on QED and performance is a unique contribution to the literature. Though there have been some discrepancies in studies in which the effectiveness of those two attentional focus strategies have been compared, others (e.g., Lidor, 1991; Singer & Lidor, 1993) have suggested that both strategies might be beneficial. However, whether these strategies really influence visual attention and in turn performance has not been seriously researched yet. Investigating the influence of external and internal focus strategies on QED and performance should provide important information about visual information processing and motor control. Furthermore, the addition of induced competitive anxiety should provide additional knowledge in this area.

Third, the results of this study should add to the data base established in related investigations (e.g., Ko & Singer, 1998; Lidor, Tennant, & Singer, 1996; Singer, Lidor, & Cauraugh, 1993) that have shown that novice performers can benefit from the adoption of expert-like strategies. Fourth, included in this study was a comparison of the effectiveness of two different strategies (external focus versus internal focus, e.g., Lidor, 1991; Lidor et al., 1996; Ko & Singer, 1998; Singer, Lidor, & Cauraugh, 1993, 1994). Although some results have indicated the usefulness of both strategies, the hypothesized superiority of an external focus strategy over an internal focus strategy has not documented substantially. A comparison of strategies along with the QED measure might provide more convincing comparison data and therefore clarify the relative effectiveness of the two attentional focus strategies.

Fifth, only a few studies have addressed the effect of anxiety on QED in relation to performance. The present study will provide more data in this area and extend the knowledge base. Sixth, the anxiety-performance relationship was analyzed. From a theoretical point of view, the data should contribute to an understanding of the interactive effects of anxiety components on performance. With the use of the modified CSAI-2, the direction of anxiety symptoms (facilitative or debilitative) and their consequence on performance were observed.

In summary, this study not only investigated the relative effects of attentional strategies on performance. Incorporated also were measures of anxiety and QED, which are assumed to influence performance. By studying performance related to these variables, and the interactions as well, more information and a deeper understanding will be gained about the focus of attention, attentional strategies, anxiety, and performance.

CHAPTER 2
REVIEW OF LITERATURE

This literature review is divided into three parts. The first part is focused on the issues associated to visual attention and eye movements based on the information processing paradigm. Emphasis is on the relationship between visual attention and sport performance in self-paced skill situations. This part also includes current methodology used to measure eye movements as well as criticisms of the visual attention paradigm. The second part discusses cognitive strategies for learning and performance enhancement. Especially, strategies related to internal versus external focus of attention is discussed in detail. In the third part, theoretical perspectives on the anxiety-performance relationship are presented, as well as potential facilitative and debilitative aspects of competitive anxiety.

Visual Attention and Sport Performance

Various sources of information (from external visual and auditory ones to internal proprioceptive ones) can be used in determining the appropriate movement decisions and execution. Perhaps, visual information is the most important source of information used to acquire skills and to maintain them (from simple ones as finger tapping to complex ones such as required in gymnastics). For example, Gavrisky (1969) and Schmidt and Lee (1999) suggested that majority of the sensory information received and attended to by performers in sport situations is obtained through the visual system. Human beings have a limited attentional and cognitive capacity to process information (Magill, 1998;

Schmidt & Lee, 1999). With the assumption of a human being as an information processor with such limitations, selective visual attention has a significant role in motor skill performance.

Selective visual attention and related eye movements are supposed to be very crucial for picking up relevant visual information in various sport settings. In an externally-paced (or open) skill situation, such as basketball, players continuously move their heads and eyes to determine the position of opponents and teammates, the location of the ball, and the distance to the goal. Due to the fast changing and dynamic nature of this sport, a player needs to make maximal meaning of minimal cues because there is usually a very short time to make change and to make decisions and appropriate actions. In contrast, players in a self-paced (or closed) skill situation such as golf do not have to make quick decisions. They usually have sufficient time to determine the location of the ball, the location of the green, and the distance to the hole. In this case, the nature of visual attention is quite different from that used in externally-paced skill situations.

In either case, the relationship between appropriate visual attention and level of sport performance is quite meaningful. Recent technological advances in eye movement monitoring instruments allowed the simultaneous recording of a sport performer's eye fixation patterns, ocular functions, and motor behaviors in various situations (Vickers, 1996b). Such technology contributes to more understanding of visual search and performance.

The following section included a discussion on visual attention and eye movements related to sport performance. The first half of the section presented issues related to visual attention research, properties of the eye, types of eye movements, and

methods of measuring eye movements. General research findings in the sport domain, especially concerning target aiming tasks, were discussed in a later part of the section.

Concepts in Visual Attention and Eye Movement

Visual attention refers to the process of selecting a portion of the available visual sensory information for object identification and localization (Yantis, 1996). Visual search is the process of directing visual attention to locate appropriate environmental cues (Magill, 1998). Scientists have studied the relationship between eye movements and underlying cognitive information processing for years (e.g., Abernethy, 1993, 1996; Brogan, 1988; Just & Carpenter, 1976a, 1976b, 1980; Neumann, 1990; Posner, 1980; Vickers, 1996a, b; Viviani, 1990; Wright & Ward, 1998). Early studies, such as the one reported by Just and Carpenter (1976a), involved a moving window paradigm in a reading task. A decrement in performance of word recognition and comprehension was shown as the speed of moving window increased. Results in early studies implied the notion that cognitive processes control the location and duration of eye fixations. In other words, the eyes were regarded as a spotlight or a TV camera which are controlled by the cognitive process to be directed to the important visual features in the environment (Viviani, 1990). In fact, researchers concerned with visual attention have assumed this relationship between the movements of eyes (which are observable) and cognitive processes (which are not directly observable) as a rationale for recording eye movements.

However, that presumed relationship has been criticized. As Abernethy (1988b) pointed out, what a person is looking at does not necessarily mean what the person is attending to. Indeed, it is possible to attend to a feature in the environment without moving the eyes to focus on that feature, and several studies (e.g., Klein, 1994;

Remington & Pierce, 1984) demonstrated this possibility. Viviani (1990) addressed the criticism to the notion of "central dogma" which posits that "exploratory eye movements can at the very least be considered as tags or experimentally accessible quantities that scientists can observe to understand underlying process of cognition" (p. 354). He argued that the strictly serial nature of eye movements proposed in the central dogma concept was challenged by other perspectives, such as parallel processing models (e.g., Rumelhart & McClelland, 1988), which suggest that visual processes can occur in parallel. Viviani also stated that another assumption of the central dogma, that attention coincides with the line of sight, is inappropriate in pre-cueing situations. Posner and Cohen (1984) supported this idea by demonstrating that visual attention can be directed to almost anywhere in the visual field, regardless of the line of the sight.

Although scholars have questioned the validity of the central dogma, it has nevertheless served as the basis of research in which eye movement recording devices have been used. Magill (1998) wrote that "eye movement recordings may underestimate what a person is visually attending to. However, with this caution in mind, these recordings provide reasonable estimates of what a person is attending to" (Magill, 1998, p. 116). Researchers have compared experts and novices in a sport as well as in other domains, and have shown evidence that certain degree of cognitive processing is associated with specific patterns of eye movements. More details about this research in sport will be discussed later in this section of the paper.

Two Mechanisms of Visual Attention

The orientation of visual attention and subsequent eye movement activity have been thought to be controlled by two different control mechanisms. Visual attentional

control is supposed to be stimulus-driven or bottom-up when the attention is captured by objects or events in the visual field that are independent of the current behavioral goals of the observer. Startle responses or attention captured by abrupt visual onsets (Yantis & Jonides, 1984) are examples that show this exogenous visual control mechanism. On the other hand, attentional control is supposed to be goal-directed or top-down when visual selective attention is oriented to objects and events in the environment which is consistent with the current behavioral goals of the observer. The example of this indigenous control mechanism in baseball is a batter's visual orientation, which is focused on the pitcher's arm area, the release of the ball, and the location, speed, and type of the pitched ball, leading to a decision to swing the bat or not to swing the bat. These two attentional control mechanisms are considered to be working together to make selection of visual information efficient and adaptive in the environment.

Whether attention can be captured exclusively by the bottom-up mechanism or by the top-down mechanism has been a controversial issue in cognitive psychology, and several researchers (e.g., Folk & Remington, 1993, 1996; Gibson & Jiang, 1998; Yantis & Hilstrom, 1994; Theeuwes, 1992; Yantis & Jonides, 1984, 1990) have addressed this issue. The data do not generally support the notion of exclusive stimulus-driven attention capture except for cases in limited conditions, such as abrupt visual onsets of stimulus. For example, findings by Folk and Remington (1996) and Yantis and Jonides (1990) indicated that attention captured by distracters, which is aligned with a stimulus-driven mechanism, could be eliminated when the attentional responses to the distracters were habituated. In other words, observers can suppress or override attention shifts to stimuli that suddenly appear in their visual field.

Overall, investigations have indicated that directing attention is more related to a top-down mechanism rather than to a bottom-up mechanism. Without that capacity of a top-down mechanism to suppress or override a bottom-up mechanism, distraction would occur to many irrelevant events. Therefore, it may be concluded that although there is almost always some interaction between these two control mechanisms, and that the capturing of attention by only one of the two control mechanisms could happen only under extremely limited conditions (Folk & Remington, 1996), forms of visual attention control would be ultimately dependent on the goal-directed, top-down mechanism.

Hardware of the Visual System

The visual system consists of several components in the central nervous system which turns "what you see" into "what you perceive". They include the eyes (peripheral organs of vision), lateral geniculate nuclei (mid-brain way-station for processing), optic chiasm (crossover paths which enable sensing data received on the retina of both eyes to be integrated as a complete image), and visual cortex.

Eyes are the peripheral organs of visual system and the primary sensor of the brain. They work in a complementarily and interactively and serve as the pick-up point of light reflected from objects in the optic array (Williams, Davids, & Williams, 1999). The retina is an important part of eyes which translates light into nerve signals allowing vision to take place. Reflected light arriving at the retina is translated into neural signals via five different layers of cell receptors: Cones and rods, horizontal cell, bipolar cells, amacrine cells, and ganglion cells.

There are two different types of receptors in the retina. Cones are responsible for details and color vision, while the rods are responsible to light and motion but not to

color and detail (Schiffman, 1996). The retinas are functionally organized. Thus, the maximum resolution of spatial detail can be obtained at a point when objects in the environment are fixed (Williams, Davids, & Williams, 1999). This area is called the fovea, which is a very small part of the retina with a high concentration of cone receptors. Therefore, this area is specialized for enhanced acuity and inspection of detail, whereas the peripheral retina with a predominance of rod receptors is specialized for fine discrimination and vision under low level of illumination. Generally, the neuronal pathway from the retina to the visual cortex, mentioned earlier, can also be differentiated into two specialized lanes of processing, referred to as magnocellular and parvocelluar projections.

Parvocelluar layers are designed for high spatial acuity, color-sensitivity, and responsivity to motion detection, while magnocellular neurons are sensitive to contrast and motion (Schiffman, 1996). It has been thought that these two subdivisions represent specialized functional streams of information that remain separated at the primary visual cortex. The magnocellular pathway protracted from the primary visual cortex to the posterior parietal cortex (ventral stream) is proposed to be involved in the perception of movement and spatial location. The parvocelluar pathway extends from the primary visual cortex via the dorsal stream to the inferotemporal cortex, and is involved in the recognition of objects. However, Milner and Goodale (1995) indicated that there is far more integration between these pathways. They suggest that the ventral pathway may be critical for the visual perception of objects, while the dorsal pathway mediates the required sensory-motor transformation for visually-guided actions directed at those objects.

From this hardware point of view of the visual system, many researchers in psychology as well as in the sport sciences have questioned whether there are quantifiable differences in visual hardware functions between experts and novices. These hardware functions include static visual acuity, dynamic visual acuity, contrast sensitivity, depth perception, and peripheral vision. Research findings suggest that skilled performers do not have superior visual hardware functions compared with less skilled performers (Abernethy, 1988a, 1993, 1996; Abernethy, Wood, & Parks, 1999).

Types of Eye Movements in Sport

Human eyes move almost ceaselessly and effortlessly by the action of the ocular motor muscles. Eyes can be fixated on a specific target and can be moved effectively, so that the image of moving stimuli continues to fall accurately on the central area of most acute and clearest vision, the fovea (Schiffman, 1996). There are many different types of eye movements and these movements are classified in to three main types and many sub-classes movements (for more detail, see Carpenter, 1988). Next, four types of eye movements, which are considered to be most related to sport performance (Williams et al., 1999) are discussed.

Eye fixations.

Eye fixations most likely represent the most important kind of eye characteristic that visual search researchers concerned with sport have studied. In sport situations, such as soccer, visual fixations enable the performer to stabilize an informative area of the display, such as a ball or a player in foveal vision, enabling more detailed processing to occur. The fixation duration has been assumed by scientists to indicate the relative importance and complexity of the display area to the observer. Thus, the duration of the

eye fixation is considered to be closely related to the amount of information to be processed (Carpenter, 1988; Just & Carpenter 1976a, b; Viviani, 1990). For this reason, fixation duration varies greatly depending on the complexity and nature of the task and on the type of visual display presented to observers (Abernethy, 1988b; Abernethy & Russell, 1987a, b; Viviani, 1990).

Saccadic eye movements.

One of the most frequent eye movements not only in typical everyday situations but also in sport is supposed to be saccades (Williams, Davids, Burwitz, & Williams, 1993). They are very quick and abrupt shifts between one fixation to another. A saccade can be very small (less than 3 degrees of a visual angle) or large (more than 20 degrees of a visual angle), and its direction and distance are planned by the nervous system prior to execution of the movement (Schiffman, 1996). In sport situations, a team player may use saccadic eye movements to scan quickly from one player to another or from a ball to a target. Saccade is a eye movement to a new fixation point, thus it enables another informative area of the display to be fixated on. During saccades, visual sensitivity is reduced dramatically (Kowler, 1990; Schiffman, 1996). That is, visual information cannot be acquired during saccadic eye movements. This reduction in visual sensitivity, called saccadic suppress, can be explained by either central or peripheral limitations in capacity (Williams, Davids, Burwitz, & Williams, 1993).

Due to the suppression of information processing during saccadic eye movements, certain visual search strategies that involve fewer fixations (consequently, a reduced need for saccadic eye movements) with longer duration are regarded to be more effective (Williams et al., 1994). At least in some particular situations, a more selective and

efficient visual search pattern may involve fewer fixations of longer duration. Therefore, this allows more time for analyzing stimuli rather than for using more saccadic eye movements to search through visual environment.

Pursuit tracking eye movements.

Pursuit tracking movements enable the eyes to track a relatively slow-moving object in the visual field, such as a ball or an opponent in football, so that a stable retinal image can be maintained in the foveal area (Williams et al., 1999). Unlike saccades, pursuit eye tracking is almost completely automatic, requiring a physically moving stimulus (Kowler, 1990). Usually, it is used to pursue an object moving slowly in a stationary environment. Thus, target velocity is more important than target location (Schiffman, 1996). In other words, if nothing moves in the situation, there is no pursuit tracking eye movement. Because the maximum velocity of pursuit eye movements is relatively small, which is about 100 degrees/sec (Rosenbaum, 1991), use of pursuit eye movements in sports is limited to situations such as watching flight of the golf ball after swinging, following a floating serve in volleyball, or tracking the movements of players on the soccer field. In sports requiring rapid changes of the visual array such as table tennis, experienced players do not use the pursuit tracking movements. Instead, they use saccadic eye movements to predict the future position of the ball (e.g., Ripoll, 1989; Ripoll & Fleurance, 1988). In addition, saccades and pursuit movements are only two general planning mechanisms that involve controlled movements of the head in directing eyes to the target (Mack, Fendrich, Chambers, & Heuer, 1985). Most investigations related to visual search in sport have tended to concentrate on fixations and saccades rather than on pursuit tracking eye movements.

Vestibulo-ocular eye movements.

The vestibulo-ocular eye movement (or vestibular ocular reflex) serves to stabilize gaze and ensure clear vision during head and body movements (Williams et al., 1999). In other words, this reflexive movement compensates for head and body movements so that one can maintain fixation on a specific target in the environment. In dynamic sport situations, it is primarily used to maintain visual clarity. For example, a tennis player attempting to pick up information from an opponent's intentions can achieve this either by initiating saccadic eye movements to bring the opponent into foveal vision or, alternatively, by moving the head while keeping the eyes fixed. The vestibulo-ocular system consists of several organs located in the inner ear, which monitor motion of the head (Rosenbaum, 1991). According to Lee and Zeigh (1991), this system enables the performer to produce compensatory eye movements much quicker (about 16 ms) than changes associated with the use of the visual system alone (about 70 ms). Therefore, the head, body, and oculormotor control system function as one highly integrated system while performing skills (Guitton & Volle, 1987).

Eye Movement Monitoring Techniques

Since the beginning of research related to eye movements, scientists in various fields have developed several techniques to monitor them. One of the traditionally used methods is electro-oculo-graphy (EOG), which involves electrodes placed around the eyes to register potentials that change synchronically with eye movements (Carpenter, 1988). As technology advanced, however, several alternatives were developed. The most recent and popular technique reported in research in the sport domain is the head-

mounted corneal-reflection method using infrared light (William et al., 1993). Different eye monitoring techniques are briefly described next.

Monitoring eye movement by altering current (AC)

This technique was developed by Anderson (1987) as a better alternative to the conventional EOG method for measuring eye movement, which depends on direct current (DC) amplification. Both techniques are based on the idea that the potential difference existing in the eye changes with movements of the eye. Such changes of the potential can be recorded with electrodes placed around the eye. However, the common electrooculographic method using DC amplification has a major disadvantage. The output signal does not correspond accurately to the input signal because the presence of electrode drift causes an unstable baseline (Anderson, 1987). With altering current (AC) amplification, the output signal returns exponentially to the baseline (Anderson, 1987). In the field of electro-nystagmography, Anderson has used this method to examine micro-level deviations of eye movements, including micro–tremor.

Due to some disadvantages which are common to all of the electrooculographic techniques, application of this method for sport contexts would be rather limited to laboratory situations. Anderson's procedure especially requires a subject to restrain movements of the head, so it would not be suitable to use it in dynamic sport settings.

Monitoring eye movement by an ultrasonic method. According to Takeda (1987), analyzing human eye movement patterns by projecting images of unborn babies ultrasonically was attempted by Birnholz in early 1980's. Since then, only a few researchers beside Takeda have used the ultrasonograph with such instruments as a ZD-252 ultrasonic device to record eye movements. The advantage of this ultrasonic method

is that (1) closed eye movements can be recorded, and (2) artifacts are fewer and any amplitude of movements can be measured.

However, this method also has some serious disadvantages. Because air prevents the passage of the ultrasound, the subject needs to stay under water. Furthermore, this method can not be used for long-term recording. The position of the subject also adds difficulties in the recording of eye movements during an experiment. Consequently, application of this method in sport contexts would be very limited. Perhaps in limited cases of under-water activities, this method could be useful for recording eye movements.

Electromagnetic recording techniques

This technique uses electro-magnetic changes in the magnetic field to detect eye movements. A common set-up is the placement of several coils on the eye (eye coil) and around the head (head coil). "A uniform alternating magnetic field which is generated by the head coils induces an alternating voltage in the eye coil, the amplitude of which is proportional to the sine of the angle between the plane of the eye coil and the direction of the magnetic field" (Carpenter, 1988, p. 422). Then, the detected signal corresponding to the eye movements can be amplified and used for recording eye movements. By employing several alternating fields, researchers can monitor eye movements in all three axes. The eye coil can be attached to a contact lens, or to a scleral ring which is attached in the same way as a contact lens but with smaller inertia.

Carpenter's (1988) technical innovation was the use of soft contact lens because it eliminates the requirement of anesthesia. He commented that this method can be also highly sensitive and accurate because the noise level can be very small. It could be used in dynamic sport contexts because the entire equipment is fairly small and is therefore

convenient. However, there may be a time limit of use because of safety reasons, and this method is rarely reported in sport psychology research.

Monitoring eye movement by a corneal-reflection method

This method is based on the principle that the reflection of infrared light placed in front of the cornea forms a near image behind the surface which can be recorded in to video. The reflection of this light source on the central portion of the cornea is assumed to be a point of eye fixation. A change in the point of eye fixation means a simultaneous change of the position of the cornea, which can be monitored and recorded by the corneal-reflection monitoring system. Early instruments were very bulky, heavy, and expensive. Thus, research was conducted mostly in laboratory settings (Williams, Davids, & Williams, 1999). However, due to recent technological advances, smaller and practical portable instrumentation is available today.

One of the most popular corneal-reflection systems used in sport situations in recent years is the NAC Eye Mark Recorder and the ASL Series 4000 systems (Applied Science Laboratory, 1997). Compared to the other eye movement measuring methods, these systems are compact, convenient to use, and portable, which means, for example, that a subject can wear the head gear and move his/her body. However, these systems have certain problems related to accuracy, measurement range, calibration, recalibration frequency, subject discomfort, set-up time, and the time required for data analysis (Williams et al., 1993). These problems have prevented the use of the corneal-reflection method in research in realistic sport settings involving free movement of the body, though some developments have occurred in this regard in recent years. The need for frequent recalibration even after a small positional change by the subject, and high

sensitivity to ambient light, can contribute to error of inaccuracy during eye movement recordings. In addition, these circumstances probably contribute to high intra-subject variability as well as inter-subject variability during testing (Williams et al., 1993, 1999).

However, technological advances have reduced many of those difficulties. More advanced systems, such as the ASL model 5000 series eye tracking system (Applied Science Laboratory, 1997), with improved software, incorporates a head tracker which can measure simultaneous head and eye movements in experiments in dynamic sport contexts, under certain conditions. Although there are still some technical difficulties, the corneal-reflection method appears to be very promising for research purposes.

In summary, the accurate and reliable measurement of eye movements in sport contexts is not an easy process. Because of the highly dynamic and complex nature of various sport activities which require free body movements, none of the techniques reviewed are fully suitable for various real sport settings. However, with rapid technical developments in the electronics and computer industry, current measurement techniques for eye movements are becoming more useful in sports contexts. Among the reviewed methods, the corneal-reflection technique appears to be best suitable in many sport settings to measure eye movements accurately.

Visual Attention Research in Sport

The role of visual attention in sport is to bring important information into fovea vision during sport situations. The role of visual search strategies, especially as associated with expertise, is challenging to determine. The visual search literature (e.g., Abernethy, 1991a, b, 1993; Abernethy et al., 1999; Williams et al., 1993, 1994, 1998; Vickers, 1996a, b) has suggested that the characteristics of eye movements, such as

fixation location and duration, represent the perceptual strategy used by the performer to extract meaningful information from the visual environment in order to perform well. In general, fixation location is considered to reflect cue pick, if necessary in human visual information processing, and the duration and number of fixations (i.e., search rate) are assumed to indicate the information processing demands for the performer. This general principle is sometimes called the eye-mind assumption (Frehlich, 1997; Just & Carpenter, 1976a, b; Viviani, 1990).

Since the initial publications of Bard and her colleagues (e.g., Bard & Fleury, 1976), many researchers have investigated differences in visual search strategies with groups of athletes. Researchers mainly adopted a skill-based difference paradigm (i.e., the expert versus novice paradigm) in their studies, and typically, filmed opponents were used to simulate real sport situations. In general, it has been assumed visual strategies are decided by task-specific knowledge structures stored symbolically in long term memory. These knowledge structures direct the performer's visual search strategy toward more important areas of the display, based on his/her past experiences (Abernethy, 1991b; Abernethy & Russell, 1987a, b). For example, Norman (1976) suggested in his pertinence-based model that skilled sport players have acquired knowledge of the most informative aspects of the display situation as a result of their sport-specific experiences. Although findings of visual search studies in sport are complicated and even contradictory in many cases, certain differences between experts and novices have been found.

In general, more skilled performers have shown fewer fixations of longer duration (i.e., low search rate) than less skilled performers to relevant cues. In other words, the

expert's visual search patterns are usually more systematic and efficient in various sport situations, including soccer (Williams et al., 1993), tennis (Singer et al., 1996), and volleyball (Vickers, 1996a, b). However, contradictory results (high search rate) have also been found in dynamic sport situations, such as table tennis (Ripoll, 1989) and soccer (Williams et al., 1994). Such contradicting findings could be due to problems of ecological validity (research is typically undertaken in laboratory situations), technical difficulties of eye movement recordings, trial-to-trial variability, and/or task specificity (Abernethy, 1993; Williams et al., 1999). In addition, as Williams et al. (1999) suggested, the conflicting findings may also happen because performers employ different search strategies in different situations. For example, players in a team sport, such as soccer, may be characterized by higher search rates when attempting to recognize team attacking patterns versus defensive structure, whereas lower search rates may be activated in more specific, familiar contexts. Thus, researchers need to consider factors such as task characteristics and task demands when they investigate visual search strategies in sports.

Any discussion on visual attention in sport requires a consideration of the nature of the differences between externally-paced (open) situations and self-paced (closed) situations. The characteristics of each are described next, with implication for attention and visual search strategies.

Externally-paced sport situations

In externally-paced sport situations, the environment is continually and unpredictably changing; hence, it is very difficult for performers to effectively plan their movements in advance (Schmidt & Lee, 1999). An example of this is seen when a soccer

player breaks away in the direction to the goalkeeper. The player has to decide whether to go forward, left, or right, or to pass the ball to a teammate, but the final decision depends heavily on what the goalkeeper and other defenders are doing. Because time is critical in this situation, success in an externally-paced skill seems to be determined by the skill level and mental quickness of the performer. Generally, in this situation and many others in a variety of sports, the ability to anticipate and to attend to task-relevant cues, to process information quickly, to make accurate decisions early as to what to do, and to execute in a timely manner is a key to successful performance. Singer (1995) stressed that not only is physical or motoric quickness important but that mental quickness is also critical in skilled behaviors.

Much information processing has to occur prior to the action itself in order to overcome the time constraints and uncertainty in externally-paced sport situations. Attention to the most salient opponent cues, an awareness of an opponent's tendencies and anticipating his/her intentions, and making good decisions in response to the opponent's actions constitute the mental quickness process that enables one to be effective in these types of situations (Singer, 1998). A visual search strategy for meaningful cues as to an opponent's intentions can be considered as one primary component of quickness. The basic assumption is that the characteristics of eye fixations reflect the underlying perceptual strategies used by the performer to selectively attend to and make meaning of relevant cues (Abernethy, 1993).

Visual scanning and eye movement research (e.g., Abernethy & Russell, 1987a, b; Bard, Fleury, & Paillard, 1990; Singer, 1995; Singer et al., 1996) has indicated that the scanning patterns of experts are more efficient than those of novices. This ability to

selectively attend to salient advanced cues and to extract meaning is essential for superior anticipation in highly dynamic externally-paced sport situations. Specific findings, with such ball sports as tennis and soccer, have indirectly verified theses conclusions. For example, Goulet, Bard, and Fluery (1989) monitored eye movements of tennis players while viewing a videotaped serve, as did Singer et al. (1996), who also used videotaped game strokes. Experts were observed to mainly fixate on the arms and racquet to determine the outcome of the opponent's shot, whereas novices fixated more than experts on the opponent's head or on the ball. Experts seemingly fixate on more proximal anticipatory cues, which may have higher predictive potential due to their experience and more task-specific knowledge base. Furthermore, Singer et al. (1996) concluded that expert tennis players were more effective than beginners in accurately anticipating the type and direction of the tennis service, at least partly due to their more efficient visual search strategies.

In Helsen and Pauwels' study (1992, 1993), participants acted as soccer ball handlers as they viewed slides of typical attacking situations. Each participant indicated as quickly as possible whether he would shoot at goal, dribble around the goalkeeper or opponents, or pass to a teammate. The results indicated that experts took less time to make decisions, and more importantly, eye-monitoring results implied that the experts gained this time advantage because they knew what to look for in a scene. A similar study by Williams et al. (1994) also supported these results. It showed that experienced soccer players fixated more on the positions and movements of other players to the contrary of inexperienced players who typically fixated on the ball and the ball handler. In other words, experienced players look at different features in the environment to make

decisions because, unlike inexperienced players, they know which ones are most important and relevant to their own decisions and actions.

Self-paced sport situations

In contrast with externally-paced situations, self-paced situations are comparatively stable and predictable, and therefore make quite different task demands. In self-paced acts, such as darts, archery, shooting, billiards, golf, and the free throw shot in basketball, performers usually have enough time to analyze the situation and to prepare for execution. The act is performed under relatively predicable conditions (Schmidt & Lee, 1999). Attentional control and direction can be self-regulated. However, it is easy to become distracted and to lose focus. Distracters in this situation could be external, such as auditory noises and visual distracters, or internal, such as self-doubt and self-awareness. In order to overcome theses potential distracters, the ability to focus attention effectively is the key to proficiency. In this regard, visual gaze, as an indication of focused attention, usually distinguishes experts from novices.

Researchers have studied various self-paced motor tasks for many years. For example, in a study (Ripoll, Bard, & Paillard, 1986) with basketball free-throw shooting, experts oriented their gaze toward the basket sooner, and made a great number of fixations with longer duration toward the target, than did novices. In addition, more successful shots were characterized by longer durations of fixations to the hoop during the preparation and flight phases of shot (Vickers, 1996a). In pistol shooting, experts were noted to maintain their fixation on the target throughout all phases of the aiming action, while novices tracked the sight of the gun until they made a fixation on the target immediately prior to pulling the trigger (Ripoll, Papin, Guezennec, Verdy, & Philip,

1985). In an analysis of a golf-putting task, Vickers (1992) reported that experts seemed to possess better use of gaze behavior compared to non-experts. Specifically, experts made more express saccades. They had quicker saccades between gaze locations and demonstrated significantly more fixations of longer duration to the ball and target hole during preparation for executing putting stroke. On the other hand, novices often tracked the putter head immediately prior to contact with the ball, and allocated fewer fixations to the ball during the contact phase of movement.

In recent studies, Vickers (1996a) investigated athletes' control of visual attention while performing a far-target aiming task (the target located farther than the length of an arm). Expert and near-expert basketball women players performed successful and unsuccessful free throws while an integrated system (ASL 3100 eye tracker with an synchronized external camera) monitored both internal (eye movements) and external behaviors (the free throw) at the same time. Six eye fixation locations (the ball, the subject's hands, the front hoop, the middle hoop, the back board, and the out of range) were identified, and data were coded to obtain information about eye fixation location, eye fixation duration, eye fixation number, and search order. Expert players showed fewer visual fixations. Furthermore, they exhibited a longer fixation duration (quiet eye) to the basketball hoop during the preparation period prior to the shot than near-expert performers. Quiet eye duration (QED), as defined earlier, is the period of time from the last eye fixation on the target to the first observable movement of the hands into the shooting action (Vickers, 1996a). In another study by Vickers (1996b), eight expert women basketball athletes and eight near-expert athletes performed 10 accurate and 10

inaccurate free throws to a regulation basket. Results indicated that expert athletes had significantly longer QED than that of near-expert athletes during the shooting action.

Later, Frehlich (1997) compared higher-skilled billiard players and less-skilled billiard players under different time constrained conditions and different task complexity conditions. The results supported the findings of previous research by Vickers (1992, 1996a, b) and indicated that the quiet eye duration was highly related to the performance of a billiard shot. Moreover, highly-skilled players demonstrated a significantly longer quiet duration than less-skilled billiard players under each of the three conditions of task complexity, as well as task duration, in which time allowed to prepare and execute was constrained. The author argued that the quiet eye duration is a very critical period of cognitive programming, and provides evidence in support of the eye-mind assumption, which was described earlier in this chapter. He also suggested that QED could be an index to distinguish experts and non-experts in billiards.

The quiet eye duration is a relatively new concept and has good potential to be a useful indicator to investigate support processes for human information processing. More research is needed, with both self-paced and externally-paced tasks. Most of the visual attention research has indicated that experts possess a highly systematic and selective process of focusing their attention. Specifically, experts know what to look at in order to take in the most informative cues in dynamic situations as well as in static situations. In comparison, novices are characterized by random and less uniform visual tracking patterns and do not appear to understand the relative importance of the link between advance visual cues and effective response preparation (Abernethy, 1991b).

Though there are still controversies to be resolved, the study of eye movements with a skill-based difference (expert-novice) paradigm appears to be well-established. Research needs to be extended to various sport applications. If findings can lead to the development of an effective visual-oriented learning strategy for performance enhancement, this would be helpful to athletes, coaches, physical educators, and especially for beginners in various sports. To do this, more environmentally (ecologically) valid investigations should be undertaken. Many studies have been conducted in the laboratory with simulated sport conditions and the use of video-taped sport scenes. Technical difficulties and problems related to real field settings are still huge and hard to avoid. However, some sport-type events can be studied under conditions in a laboratory. For instance, darts is one example. In addition, elements of competition can be added as in a real sport competitive situation. The influence of competition and anxiety/arousal on visual search strategies and performance should reveal interesting data, and is the topic of interest in my proposed study.

In summary, scientists in motor behavior have believed that various patterns of eye movements, while performing motor skills, reflect the influence of internal cognitive processes. They have investigated this relationship between eye movements and underlying information processing using various eye movement registration techniques such as a corneal reflection method. Among various eye movements, duration and frequency of eye fixation have been a primary interest. Many studies in sport, which typically used filmed-opponents and the novice versus expert paradigm, indicated that experts use more efficient and effective visual search patterns than novices do. Especially, for QED in self-paced motor skills, these differences are evident. However,

only a few studies related to QED have been published. Further investigation should contribute to the body of knowledge on QED, (1) determining optimal time duration, (2) how to influence it with relevant cognitive strategies, and (3) how to adopt the QED without being distracted by competition conditions that might heighten arousal/anxiety.

Cognitive Learning Strategies in Sport

Differences in learning and performing sport skills between athletes can be attributed to many factors, such as physical characteristics, opportunities, prior experiences, motivation, and various psychological characteristics. Differences can also be attributed to the use of appropriate strategies for learning and performing sport skills (Singer, 1984). In the hardware point of view, both successful players and less successful performers seem to have similar capacities to process information, but successful performers may process information more appropriately. In other words, experts may use better cognitive strategies than less successful performers. Cognitive strategies represent a sequence of higher-order mental procedures that influence information processing positively. Learning and performance situations are improved and achievement outcomes are enhanced (Chen & Singer, 1992). Therefore, appropriate strategies should help individuals to influence their ability to acquire new sport skills and to perform already well-learned skills more successfully. According to Singer (1984), cognitive strategies generally:

1) Can be self-generated or imposed from external sources.
2) Involve the development of rules or principles. They can be applied effectively to similar situations.
3) Require repeated attempts in situations to become effective.

4) Are probably used differently by experts and novices.

5) Even differ among the high skilled, due to the nature of individual differences.

The terms, learning strategy and performance strategy, have been used synonymously in the research literature, because various cognitive strategies have been applied to enhance the acquisition of new skills and to improve performance of already learned skills. However, a more clear classification and differentiation are desirable. For example, Singer and Chen (1994) classified the terms according to purpose. Learning strategies primarily contribute to the acquisition of skill, as in a practice situation, whereas performance strategies contribute to the production of what has been learned on evaluative occasions (e.g., competition event). During practice, athletes try to perfect skills and tactics, as well as their strategies. Some trial and error is obviously needed. More intentional cognitive intervention occurs during practice than in actual competition. Not only mechanical skills and techniques, but also thought and emotional processes are trained and refined during practice (Singer, 1984).

In competition, however, deliberate consciousness is reduced, and movement seems to flow, at least for the expert. Conscious intervention is used only when appropriate. "Things just seem to happen", if everything is going right. This kind of expression can be frequently heard from athletes upon completing an outstanding performance. Cognitive strategies for performance enhancement are preplanned. Skills, tactics, and all the necessary strategies have been well-learned; thus, deliberate attention to them may not be necessary (Singer, 1984). Pask (1975) suggested that both learning and performance strategies require the use of mental subroutines to accomplish goals. Learning strategies could help solve problems, such as deficiencies in the repertoire of

performance strategies. Therefore, learning strategies could be defined as a form of guidance for learners to acquire skills, as well as a plan for selecting performance strategies and building or rectifying them (Singer, 1988).

<u>Concepts of Cognitive Learning Strategies</u>

The investigation of general and specific learning strategies was initiated presumably by educational psychology researchers. They have studied effective learning strategies for students and how these strategies might be taught to those who do not use them, or do not use them properly. Norman (1980) stated that "we need to develop the general principles of how to learn, how to remember, and how to solve problems" (p. 97). By informing learners about appropriate strategies, they should understand when to activate pertinent cognitive processes, and which ones, in a timely manner. As a result, students ultimately would know more about how to manage their cognitive processes, and how to analyze themselves and situational demands. This enables them to achieve in present situations and to adapt to future related situations, once a formal instructional program has been completed.

Weinstein and Mayer (1986) have suggested five types of general learning strategies for educational purposes.

1) Rehearsal: being involved in actively preparing by either saying or writing the material, or focusing attention on key parts of it.
2) Elaboration: being involved in making connections between new material and more familiar material.
3) Organization: involvement in imposing structure on the material by subdividing it into parts or clusters.

4) Comprehension monitoring: being involved in remaining aware of what one is trying to accomplish during a learning task by keeping track of the strategies one uses and the degree of the success achieved with them, and adjusting behavior accordingly.
5) Effectiveness: being involved in eliminating undesirable effects and preparing to learn.

In educational psychology, researchers (Dekkers & Thijs, 1998; Moely, Olsen, Howles, & Flavell, 1989; Reese, 1977; Rosenshine, Meister, & Chapman, 1996) have determined the usefulness of various cognitive learning strategies. For example, Reese's study (1977) indicated that an imposed imagery (a kind of elaboration strategy) can improve paired-associate learning for kindergartners and first graders. In another study, Moely, Olsen, Howles, and Flavell (1989) showed that children who were taught how to apply an organizing strategy to list learning were able to enhance their recall performance. The results of Rosenshine, Meister, and Chapman's (1996) research indicated that students' comprehension of study materials can be increased by teaching them a cognitive strategy of generating questions.

The usefulness of learning strategies has been investigated in motor learning and sport psychology as well. Furthermore, researchers have attempted to resolve a number of cognitive learning strategy issues (e.g., implicit learning vs. explicit learning; an awareness approach vs. non-awareness approach). Findings from studies in sport, as well as in other domains, will be presented in the next sections.

<u>Explicit and Implicit Learning</u>

Many scholars have argued that knowledge can be explicit or implicit (Anderson, 1982; Berry, & Dienes, 1993; Hardy, Mullen, & Jones, 1996; Hayes & Broadbent, 1988;

Masters, 1992; Seger, 1994). Explicit knowledge consists of facts and rules of which one is specifically aware and thus able to articulate. Implicit knowledge is what one knows, but may not be aware of or cannot articulate (Masters, 1992). It is widely accepted that the acquisition of a motor skill, in general, goes through three stages or levels of learning (Kluka, 1999; Rose, 1997): From a cognitive stage to an associative stage, and ultimately to an autonomous stage. According to Fitts and Posner (1967), in the cognitive stage, knowledge is explicit and rule-based, and performance is slow, has many errors, and requires much effort. In the associative stage, the emphasis on the nature of practice, errors are fewer, and performance becomes more consistent. In the autonomous stage, however, knowledge is implicit and non-verbalizable, and performance is smooth, effortless, fast, and almost automatic.

This basic distinction is common among many other theories of skill learning. For example, Anderson's (1982) adaptive control of thought theory of skill acquisition is almost the same idea as Fitts and Posner's (1967) concept, except for replacing the cognitive stage with a "declarative stage", and the autonomous stage with a "procedural stage" (Masters, 1992). Several scholars (e.g., Berry & Dienes, 1993; Hayes & Broadbent, 1988; Reber, 1993; Seger, 1994) have suggested that a skill can be initially developed without an explicit, declarative encoding of knowledge. However, many earlier investigators of skill learning have thought that acquisition of a skill begins with declarative, explicit encoding of knowledge in which the demands on cognitive processing are high, and ends with procedural, implicit encoding in which the demands are low (Masters, 1992). Consequently, many current conventional teaching methods

which are used by educators, teachers, and coaches in teaching beginners reflect the explicit nature of learning.

Whether or not the initiation of skill learning can be implicit or must be explicit, the characteristics of expertise most definitely involve an implicit, effortless, and automatic nature (Hardy, Mullen, & Jones, 1996; Masters, 1992). This implicit nature of expert performance can be converted to the explicit nature of learning, if necessary. Deikman (1969) called it "deautomatization" which he conceptualized as the "undoing of automatization, presumably by reinvesting actions and percepts with attention" (p. 31). However, as Eysenck (1992) have suggested, attempts to facilitate automated skills by isolating and focusing on specific components of the skill often result in a decrement in performance. Klatzky (1984) explored the "common notion that awareness of performance decreases with practice, and that becoming aware impairs execution of a skilled act" (p. 62). Eysenck (1984) and Schmidt and Lee (1999) also have the similar opinion that deautomatization and consequential performance deterioration could occur in even the most experienced skills. For example, "if you think too deeply about the leg movements involved in walking down a flight of stairs, you may well finish up in a heap at the bottom of the stairs" (Eysenck, 1984, p. 13).

In this perspective, Masters (1992) proposed that reinvestment of controlled processing in automatic skill may explain deteriorated performance. He hypothesized that if explicit learning is minimized, performers have less conscious knowledge of rules for execution of the skill and they have less invested knowledge in time of stress. This should result in a lower incident of skill break-down under stress. In his study (1992), novices at golf-putting were divided in to an explicit learning condition group or an

implicit condition learning group, and then performed a golf putting task under an evaluation stress condition and non-stress condition. Participants in the explicit learning group received specific written instructions on how to putt, and those in the implicit learning group performed the task under a dual-task paradigm to suppress explicit knowledge of golf-putting skill. A verbal report of random letters was used as a secondary task. The results indicated that the participants in the implicit learning group coped better with stress than those in the explicit learning group. In other words, disruption of automaticity of a skill under pressure was less likely when the skill has been learned implicitly rather than explicitly (Masters, 1992). A study by Hardy, Mullen, and Jones (1996) also supported the results of Masters' (1992) investigation. Their analysis revealed that participants in the implicit learning condition continued to improve their performance under stress while those in explicit learning condition did not. Studies in motor behavior, thus far, seem to indicate that implicit learning may be better than explicit learning for the acquisition of motor skills.

Self-awareness and Non-self-awareness Learning

Another issue with regard to learning strategies in the sport domain is whether there is any difference in effectiveness between a self-awareness strategy (internal focus) and a non-self-awareness learning strategy (external focus), which is a similar context to the explicit learning versus implicit learning approach. It has long been believed that beginners should consciously think about bodily sensations and the activity that they are learning, and to pay attention to what they are doing. In most learning situations, various external and internal cues are available, yielding relevant or irrelevant information. Traditionally, instructors and coaches in sports have believed that various sources of

information (including visual, auditory, and proprioceptive) can be used to improve performance during the acquisition of motor skills (Gallwey, 1976). In other words, if learners are able to use more explicit knowledge of information during performance and instructed as to how to become aware of it, better performance presumably will be achieved (Lidor, 1999). Gallwey (1976, 1981) was an advocate of the awareness approach for learning sport skills (e.g., tennis and golf), and defined it as a mode of learning in which individuals attempt to feel what is happening as they execute. He suggested that learners should be asked to (a) feel their movements, (b) listen to pertinent sounds, such as a tennis ball being struck by the racket, and (c) pay attention to the direction of body movements.

The idea of an awareness learning strategy for complex motor skills appeared to be plausible, and was supported by an earlier study by Cox (1933). In Cox's study, three groups (one group of children and two groups of adults) performed an industrial task involving assembling, wiring, and stripping an electrical lamp holder. The children and one adult group were given a general description of the task. The other adult group was instructed to focus on (a) visual and kinesthetic cues, (b) the manner of holding the part, and (c) control of attention and effort. Participants who used visual and kinesthetic cues performed better than those who were given general instructions. The results indicated that performance in a motor skill was facilitated best when kinesthetic and visual cues were emphasized. Feldenkrais (1972) and Ravizza (1998) have also advocated the concept of the awareness learning strategy. Ravizza (1998), for instance, suggested that "developing awareness is a critical element of peak performance because it provides athletes with the experiential knowledge to gain control (p. 178)". He also recommended

the use of performance feedback sheet, journal keeping, physiological monitoring, psychological questionnaires, and group discussion to develop awareness. However, as Singer, Lidor, and Cauraugh (1993) pointed out, the awareness approach lacked support from systematic research.

A non-awareness of self learning strategy (which is similar to implicit learning) has been proposed as an alternative to a traditional awareness learning strategy for motor skill acquisition (Lidor, 1991; Singer & Lidor, 1993). During competition, many top-level athletes seem to achieve their best performances without deliberately attending to what they are doing. They appear to be using a non-awareness strategy. Generally, when skilled experts, such as athletes, dancers, and musicians, have been asked what they thought about during their best accomplishments, they usually remember very little or even nothing. Several scholars (Csikszentmihalyi, 1990; Garfield & Bennett, 1985; Loehr, 1982) have argued that such athletes performed at their best in a non-awareness situation. For example, consciousness seems to be turned down and the "flow state" unfolds (Csikszentmihalyi, 1990), or “things just seem to happen” (Garfield & Bennett, 1985, p. 181).

In sport situations, elite athletes apparently have minimal thought about what they are doing during an outstanding performance (Singer & Lidor, 1993; Singer, Lidor, & Cauraugh, 1993, 1994). They may feel isolated from distracters, devote themselves completely in to the action with strong confidence, and feel that have all the time they need to respond accurately (Singer & Lidor, 1993). In other words, their minds and bodies are harmoniously united so that they can perform like well-tuned automatic machines. It has been believed that attaining a state of automaticity in the movement is

the goal of mastery in any situation (Logan, 1988, 1990; Magill, 1998; Schmidt & Lee, 1999).

If novices attempt to use the same approach as expert athletes use (i.e., non-awareness strategy) for learning and performing sport skills, will it be effective? The question is how to learn complex motor skills in a more efficient and effective way. Should novices follow the traditional awareness approach for learning, or should they try the non-awareness approach that is associated to what experts usually do? To answer the question, Singer and his colleagues (e.g., Ko & Singer, 1998; Lidor, 1991, 1999; Lidor, Tennant, & Singer, 1996; Singer, 1988; Singer & Lidor, 1993; Singer, Lidor, & Cauraugh, 1993, 1994) have investigated different cognitive learning strategies including self-awareness, non-awareness of self, and the Five-step strategy (FSS). The FSS is a comprehensive cognitive strategy for learning and performance, consisting of five substrategy components: readying, imaging, focusing, executing, and evaluating. It involves characteristics of both awareness and non-awareness strategies for achieving in self-paced motor skills. A non-awareness strategy involves learners performing without deliberately attending to what they are doing. Specifically, they would (a) preplan the action, (b) focus exhaustively on one cue like to a target, (c) let the movement flow, and (d) perform the act as if a state of automaticity.

Singer and Lidor (1993) proposed that the both the awareness strategy and non-awareness strategy could be useful to enhance learning. They also hypothesized that the non-awareness strategy would be better for beginners to attain a higher level of skill than the awareness strategy. Results from two different studies (Singer et al., 1993, 1994) partly supported their assertion. In the first study, participants in four groups (awareness

strategy, non-awareness strategy, FSS, and control) performed 250 trials for a ball-throwing task during an acquisition session, and then performed 50 trials in a dual-task situation (ball-throwing and verbal-report) for a retention session. The results showed participants in the non-awareness strategy group and the FSS group performed better than those in the awareness strategy group and the control group during the acquisition session and the dual task session. Singer and his colleagues compared these learning strategies again using a more cognitive-oriented task (sequential key-pressing).

In the second study (Singer et al., 1994), participants in four groups (awareness strategy, non-awareness strategy, FSS, and control) attempted 250 trials in a key pressing task in the acquisition session, and then undertook 50 trials in a dual task situation (sequential key-pressing and verbal report) in a retention session. The results indicated that participants in the non-awareness strategy group and the FSS group performed the key-pressing task faster than those in the control group during acquisition. Participants in the non-awareness strategy group performed better than those in the awareness strategy group in five blocks (including the last block) of a total of 10 trial blocks during the acquisition session. The researchers concluded that the two cognitive strategies (non-awareness and FSS) should be useful to enhance beginners' achievement in sport skills, at least in some self-paced skills. They concluded that the appropriate focus of attentional processes, which is external (like to a target), will lead to higher accomplishment. Therefore, the exclusive orientation of attention to a particular task cue, so that internal thoughts and an awareness of extraneous situational information can be blocked, seems to be a critical strategy for self-paced motor skill learning (Singer et al.,

1994). Perhaps this could be the primary reason why the non-awareness strategy and FSS have been shown to be effective.

In contrast to a study by Singer et al. (1993, 1994), a study by Lidor et al. (1996) failed to show performance differences between non-awareness strategy and awareness strategy groups during an acquisition session and transfer session involving self-paced motor skills. These results also reappeared in Ko and Singer's (1998) investigation. They compared participants in three groups (awareness strategy, non-awareness strategy, and FSS) using a golf-putting task. Though the non-awareness group displayed better scores in golf-putting consistency, no other difference was found between the two groups (awareness strategy and non-awareness strategy) during both the acquisition and retention sessions. The investigators attributed this inconsistency between the results of the studies to differences in participant numbers, differences in trial numbers, and task specificity. However, it may also be partly (at least, for retention) due to confounds by the dual-task paradigm used in the earlier studies.

These two studies (Singer et al., 1993, 1994), which showed superiority of a non-awareness of self strategy over a self-awareness strategy during the retention session as well as the acquisition session, included a dual-task paradigm during retention tests. Both studies used the verbal report as a secondary task to "impose additional processing demands on a person" (Singer et al., 1993). Recall the studies presented in the section on implicit and explicit approaches (e.g., Masters, 1992 and Hardy et al., 1996). These researchers also used a dual task method to suppress explicit knowledge (which may be very closely associated to awareness learning) in the implicit learning groups during the acquisition of skill stage. The secondary verbal tasks used in the two studies of Singer

and his colleagues (1993, 1994) might not hinder the positive influence of the non-awareness learning strategy (which has similar concepts to implicit learning), or may even facilitate it by suppressing explicit knowledge (which may be important to the awareness learning strategy) as was witnessed in investigations, such as Masters (1992) and Hardy et al. (1996). On the other hand, the secondary task might harm the positive influence of awareness learning in the awareness learning strategy group by interfering in the use of explicit knowledge.

External and Internal Focus of Learning

In the studies (e.g., Lidor, 1999; Lidor, Tennant, & Singer, 1996; Ko & Singer, 1998, Singer & Lidor, 1993; Singer et al., 1993, 1994) of cognitive learning strategies in motor behavior, the awareness strategy is one that encourages learners to attend to each act, to be aware of the task situation, and to be aware of body parts during execution. In other words, it is a strategy directing the learner's focus of attention to himself/herself, to movement itself, or more specifically to internal cues during or before performing a skill. The non-awareness strategy guides the person to perform without attending to self or a variety of situational details, but to focus on one meaningful task cue (Singer et al., 1994). In other words, the learners' focus of attention is directed to an external cue, such as a target. There has been some confusion in the definition of the awareness and the non-awareness strategies with relation to the focus of attention. Although the term non-awareness strategy suggests that a person be unaware of various internal and external cues in the environment (this is why it is also called "just do it" strategy), the reality is that the performer using the strategy still should be aware of at least one meaningful external cue. That cue, such as a target, should be focused on intently. It is very

difficult, even for a very skilled performer, to completely isolate himself/herself from all the relevant/irrelevant cues in the environment and to perform a motor skill as if in a state of automaticity.

The point is that when considering the characteristics of attentional focus in the two strategies, the internal focus strategy and the external focus strategy are more appropriate terms for the awareness strategy and the non-awareness strategy. The concept of performing in a non-awareness of self state originated from the research on the characteristics of experts when they are at their best. They appear to function as if in an automatic condition. When considering these characteristics in providing learning strategies to novice learners, it appears that exclusively orienting their visual attention to a particular task-relevant cue during performance should be beneficial. Unnecessary internal thoughts and extraneous situational information would be blocked. Therefore, at least one explicit or awareness orientation (attentional focusing on an external cue) is still retained in the strategy. For example, performers using a non-awareness strategy in darts are nevertheless aware of the target and attempt to focus on the bull's eye. In golf putting, they usually switch focus from the ball, to the hole, to the ball, and back again until comfortable, with the final focus on the ball (for more detail, see Vickers, 1992).

The terms, "external focus of attention" and "internal focus of attention" have been used in several studies of motor behavior as strategies to enhance learning and performance. Wulf and Weigelt (1997) hypothesized that directing a performer's attention to his/her own movement (internal focus of attention) can disrupt not only the execution of automated skills, but also have degrading effects on the learning of new skills. They performed two experiments using a ski-simulator to test this hypothesis. In

the first experiment, participants in an internal focus group received instructions about the timing of force on the ski-simulator (i.e., when to exert force within the movement cycle) at the beginning of practice, and then performed 20 trials of a slalom-type task. The instructions actually hampered performance during acquisition and during a transfer test in which participants performed the task under an evaluation stress condition, as compared with the performance of a control group not given such instructions.

In the second experiment, participants performed 25 trials with the same task over an extended period of time (three days of training, and three days of retention one week after the training). The instructions about the timing of force were given between the 22nd and 23rd trials to the participants in the internal focus group. The results showed a clear drop in performance after they received the instructions. Based on the results of these two experiments, the authors concluded that that the commonly used traditional instructions, which direct the performers' attention to their body movement during complex motor skill acquisition, might not be desirable.

Wulf, Hoss, and Prinz (1998) argued that instructions may be more beneficial for learners if they direct the learners' attention away from their body movement, and more to the effect that these movements have on the environment (e.g., sporting equipment such as the wheels of the ski-simulator or the target in shooting). They carried out two experiments to investigate the effects of different types of instructions on performing complex motor skills. The instructions were related either to the participants own body movements (internal focus) or to the effects of those body movements on the equipment (external focus). Experiment 1 indicated that instructing participants to focus on the force that they exerted on the wheels of the platform in a ski-simulator was more

effective than focusing their attention on the foot that exerted the force. In Experiment 2, the learning of a dynamic balance task using a stabilometer was also enhanced by an external focus of attention, where performers focused on markers attached to the platform directly in front of their feet, compared to an internal focus of attention, where performers focused on the feet themselves. The concepts and the results of the studies conducted by Wulf and her colleagues are very similar to the research dealing with awareness and non-awareness learning strategies.

Different attentional strategies were investigated by Radlo, Steinberg, Singer, Barba, and Melnikov (in press). They measured electocortical activity (EEG), heart rate, and performance in a dart throwing task. Twenty novice dart throwers were divided into either an external focus strategy group or an internal focus strategy group, and then asked to perform a total of 40 trials of underhand dart throwing at a target board while their EEG patterns and heart rate were measured. The results indicated that the external focus strategy group performed with less error than the internal focus strategy group. In addition, EEG patterns and heart rate patterns of the external focus group were different from those of the internal focus strategy group. Based on the results, the authors suggested that an external focus strategy is associated with more ideal brain wave patterns and heart rate during the performance of self-paced motor tasks.

In summary, better cognitive learning and performing strategies help individuals to regulate their mental processes effectively, thereby contributing to achievement. Traditional learning strategies which have been used in sport and physical education settings usually emphasize explicit knowledge and an awareness of various internal cues as well as external cues. However, results from recent investigations in sport psychology

indicate that an external focus strategy, which directs the performer's attention away from self to a relevant external cue during execution, may be more beneficial.

Arousal, Stress, and Anxiety

The concepts of arousal, stress, and anxiety are deeply associated with each other. Thus, these terms are frequently used interchangeably in the scientific literature. However, distinguishable and precise definitions for each of these terms is necessary in order to reduce confusion and to facilitate effective communication. The early interpretation of arousal was derived from the concept of the mobilization of energy by an organism to survive in life-threatening situations (Weinberg, 1989). Later, this concept was refined by several researchers. For example, Duffy (1962) described arousal as an intensity of behavior, which was defined as the extent of release of potential energy stored in the tissues of the organism in activity or response.

Some sport psychologists have explained arousal as a general physiological and psychological activation of human beings that varies on a continuum from deep sleep (i.e., coma) to intense excitement (i.e., frenzy) (Gould & Krane, 1992; Weinberg, 1989). In general, the shifting of arousal involves changes of physiological responses such as heart rate, sweating, respiration, and various electrical activities in the body. Alteration of arousal is not directional. In other words, it is not necessarily associated with either pleasant or unpleasant events (Weinberg & Gould, 1999). Thus, an individual could be highly aroused not only by winning a lottery, but also by losing his/her job or the death of his/her close friend.

The term stress is often interchangeably used with the term anxiety by many people because it has historically been "one of the most ambiguous psychological

constructs in behavioral science" (Martens, Vealey, & Burton, 1990, p. 6). Stress has been deemed as a stimulus, a response, an intervening variable, and a state variable. For example, it has been regarded as a state in which a demand is placed on the individual, who is then required to react in order to cope with the situation (Jones, 1990). A more comprehensive and well-accepted model of stress in the sports domain was established by McGrath (1970). He defined stress as "a (perceived) substantial imbalance between demand (physical and/or psychological demands) and response capability, under conditions where failure to meet demand has important (perceived) consequence" (McGrath, 1970, p. 20). According to McGrath's model (1970), the following four events must be considered to study stress:

1. The physical or social environment that places some objective demand on the individual.
2. The individual's perception of the demand, and the decision about how to respond to it.
3. The individual's actual response to the perceived demand.
4. The consequence resulting from that response.

There are many known sources of stress. These sources can be divided into two general areas: Situational sources of stress and personal sources of stress. Situational sources of stress are primarily associated with two factors: (a) the importance of an event or contest, and (b) the uncertainty that surrounds the outcome of the event (Martens, 1987). In general, more important events usually provoke more stress, and the greater the uncertainty, the more stress. Two important factors in personal sources of stress are trait anxiety and self-esteem. Some examples of sources of stress in sports situations are risk

of injury, presence of spectators and media, fear of losing, conflict with the coach or other team members, and the like.

Unlike arousal, which refers only to the intensity dimension of behavior, the concept of anxiety can be related to both intensity and direction. With regard to direction, anxiety has been considered by many psychologists as a negative emotional state with feelings of worry, nervousness, and apprehension associated with arousal or activation of the body (Weinberg & Gould, 1999). However, others (e.g., Hardy, 1996) have proposed that under certain conditions, anxiety can produce a positive effect on performance.

State and Trait Anxiety

Spielberger (1966) was one of the pioneers who suggested the conceptual distinction between trait (chronic) anxiety and state (transitory) anxiety. He also developed the State Trait Anxiety Scale (STAI) to measure these two separate components of anxiety. He proposed that state anxiety is defined as a transitory emotional state that varies in intensity and fluctuates over time. In other words, state anxiety is an emotional reaction involving feelings of tension, feelings of nervousness, unpleasant thoughts, and physiological changes. The physiological changes associated with increased state anxiety include elevated blood pressure, faster heart rate, faster breathing, dilation of the pupils, and increased perspiration (Weinberg, 1989). In addition, muscle tension and contraction also occur with suspension of low priority functions, such as eating and digesting.

Trait anxiety refers to "relatively stable individual differences in anxiety proneness, that is, differences in the disposition to perceive a wide range of stimulus

situations as dangerous and threatening and response to such threats with state anxiety reactions" (Spielberger, 1972, p. 39). Since individuals with high trait anxiety are more vulnerable to stress, their state anxiety reactions can be predicted to some degree. Trait and state components of anxiety in an individual have a direct relationship. This trait-state anxiety theory provides a general framework for research on anxiety, and describes possible relationships between these two variables. Research has shown that a person who has higher trait anxiety usually demonstrates more state anxiety in highly competitive, evaluative situations (Spielberger, 1966, 1972). Thus, in sport, which is highly competitive in nature, the anxiety of an athlete before or during events could be predicted by the interaction of general level of anxiety (i.e., trait anxiety) and the specific situational influences of the event (i.e., state anxiety). However, research has not always supported the relationship between the two components of anxiety.

Though knowing a person's level of trait anxiety is generally helpful in predicting his/her reaction to competition, evaluation, and threatening situations, the response of the person to stressors also depends on situation specificity (Weinberg & Gould, 1999). For example, some high trait anxious athletes could have more experience for a particular situation or learn coping skills to help them reduce the state anxiety they experience during competitions.

Cognitive and Somatic Anxiety

In the 1960's, researchers such as Liebert and Morris (1967) began to consider anxiety as a multi-dimensional rather than uni-dimensional construct. Under the multi-dimensional paradigm, they argued that anxiety is composed of cognitive-worry and emotional-arousal components. Borkovec (1976) and Davidson and Schwartz (1976)

identified those components of anxiety in the same year. Since then, the distinction of cognitive anxiety and somatic anxiety has been applied to both state and trait anxiety in the psychology literature. Morris, David, and Hutchings (1981) described cognitive anxiety as "conscious awareness of unpleasant feelings about oneself or external stimuli, worry, and disturbing visual images" (p. 547). In other words, cognitive anxiety is the concern or worry component of anxiety, and in sport situations it may be caused by negative expectations of performance, self-doubt, and lack of self-efficacy.

Somatic anxiety, however, is proposed to be reflected by physiological and affective factors that are directly related to autonomic arousal. Somatic elements of anxiety are reflected in responses such as rapid heart rate, tense muscles, shortness of breath, clammy hands, and butterflies in the stomach (Martens, Vealey, & Burton, 1990; Hardy, Jones, & Gould, 1996). Cognitive and somatic anxiety coexists in various stressful situations, because they usually contain a predisposition to both cognitive and somatic components. As mentioned earlier in this section of the paper, anxiety (cognitive or somatic) contains both intensity and directional dimensions of human behavior. Cognitive and somatic anxiety had been considered to be negative in direction due to their links with negative affect (Martens, Vealey, & Burton, 1990). Thus, high levels of cognitive and somatic anxiety had been considered to be unpleasant and harmful to performance as well. However, recent developments, such as the cusp catastrophe model (Hardy, Parfitt, & Pates, 1994) suggest interactive relationships, which are both positive and negative, between cognitive anxiety, somatic anxiety, and performance.

Recent research in sport psychology has addressed issues related to competitive anxiety based on the multidimensional framework from two different perspectives. First,

the concept of trait and state anxiety, which was initiated by Spielberger (1966), is widely accepted in the sport science literature. Secondly, competitive state anxiety is regarded as a multidimensional construct comprising two components (cognitive and somatic anxiety). These generalizations contribute to understanding the anxiety-performance relationship in sport.

Measurement of Anxiety

Anxiety has been measured using physiological measures and self-report inventories. Physiological indicators include pulse rate, blood pressure, respiration rate, and various electrophysiological measures such as EEG (electroencephalogram) and skin resistance (Hackfort & Schwenkmezger, 1993). Physiological measurements have some advantages, such as real-time measuring, but disadvantages seem to keep them from being used in sport situations. For example, different physiological indicators (e.g., heart rate and electromyograms) have shown only a slight correlation with each other (Hackfort & Schwenkmezger, 1989). In general, specific systems behave differently; that is, under each condition in mobilizing for a reaction, a certain system will become active while others will reduce their activities, and still others remain unaffected (Hackfort & Schwenkmezger, 1989, 1993). In addition, when considering that the nature of sport involves much physical activity, it is important to note that the physiological parameters change much more from the results of vigorous physical activity than by the results of stress or anxiety-inducing situations.

Various self-report inventories for anxiety have been developed and used widely. Though these general inventories, such as the General Anxiety Scale (Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960) or the State-trait Anxiety Inventory (STAI)

(Spielberger, 1966), are popular in general psychology, many researchers in sport psychology have decided on other inventories. A preference for the use of situation-specific instruments developed for sport situations has been shown. One example is Martens' (1977) Sport Competition Anxiety Test (SCAT). As several researchers, such as Magnusson and Ekehammar (1975), Martens (1977), and Martens, Vealey, and Burton (1990) have suggested, anxiety is a learned response depending on situations. Thus, the use of sport-specific inventories seems to be a reasonable way for researchers in sport psychology to examine anxiety related to sport more accurately.

Martens (1977) asserted that situation-specific questionnaires were better at predicting state anxiety than were general inventories, and he developed the SCAT, one of the first sport-specific inventories for measuring trait anxiety. When compared to the trait version of Spielberger's (1966) STAI (a general inventory), Martens' SCAT (a sport-specific inventory) has been created to be a better predictor of state anxiety in various sport situations (Martens et al., 1990; Parfitt, Jones, & Hardy, 1990). Results from a series of studies by Martens and his colleagues (e.g., Martens & Simon, 1976) have repeatedly supported the construct validity of SCAT, and demonstrated the superiority of SCAT in predicting competitive state anxiety over coaches' ratings as well as other general trait anxiety inventories such as the STAI. However, according to Hackfort and Schwenkmezger (1993), SCAT was no better than the STAI in predicting state anxiety in sport situations.

During the field validation studies of SCAT (Martens & Simon, 1976), Martens and his colleagues found that some items contained in Spielberger's STAI had little relevance to anticipatory competitive state anxiety. Therefore, they modified the STAI

by identifying 10 items that were more sensitive to state anxiety changes in competitive situations. This new scale, involving the 10 items to measure the state component of anxiety, was named the Competitive State Anxiety Inventory (CSAI) (Martens, Burton, Rivkin, & Simon, 1980). They demonstrated reliability and validity of the CSAI for adults and children, and more importantly results from these studies indicated that it was a more appropriate measure in competitive situations (i.e., sport situations). However, the CSAI as well as the SCAT were not comprised of the multidimensional aspects of anxiety, which is currently a major framework in the sport psychology literature concerned with anxiety.

Consequently, Martens, Burton, Vealey, Bump, and Smith (1990) revised the CSAI-2 as a sport-specific questionnaire which separately measures the cognitive and somatic components of state anxiety. Self-confidence, which is regarded as an important independent factor in the anxiety performance relationship (Hardy, Jones, & Gould, 1996), was included in the CSAI-2 as a third subcomponent. This scale contains a total of 27 items, and each item is designed to belong to one of three subcomponents: Cognitive anxiety, somatic anxiety, and self-confidence. Examples of questionnaire items for cognitive anxiety include "I am concerned about performing poorly" and "I am concerned that others will be disappointed with my performance", while items for somatic anxiety include "My heart is racing" and "I feel nervous". Finally, items for self-confidence include "I feel self-confident' and 'I am confident about performing well". Responses to each item are on a Likert scale ranging from 1 (i.e., not at all) to 4 (i.e., very much so). Therefore, a possible total score of three subcomponents range from 9 to 36.

The CSAI-2 has shown good constructive validity and internal consistency in various sport situations (Martens et al., 1990). For instance, researchers using the CSAI-2, such as Jones and Cale (1989) and Jones, Cale, and Kerwin (1989), have demonstrated similar intercorrelations among the three CSAI-2 sub-scales which were previously reported in the works by Martens et al. (1990). In general, the literature has indicated that the CSAI-2 is an appropriate and reliable tool for the study of multidimensional competitive state anxiety in various sport situations.

Competitive Anxiety and Sport Performance

Anxiety is a common phenomenon in competitive situations as associated with sport and the effect of anxiety on sport performance has been an important research issue. In general, the earlier literature on the competitive anxiety-performance relationship in motor behavior has been dominated by arousal-based explanations such as the drive theory or the inverted-U hypothesis. Anxiety was assumed to be an indicator of arousal (Hackfort & Schwenkmerzer, 1993; Jones, 1995; Weinberg & Gould, 1999). These approaches suggested that anxiety affected performance because changes in anxiety were closely commensurate with corresponding changes in arousal. These unidimensional approaches used in early studies to investigate the relationship between anxiety and performance were not successful (Hardy, 1990; Jones & Hardy, 1990; Parfitt, Jones, & Hardy, 1990) because the actual relationship is too complex to be explained by a simple hypothesis. Therefore, several multidimensional alternatives, such as the multidimensional anxiety model and the cusp catastrophe hypothesis, were proposed. The following section includes a discussion on the development of these theoretical frameworks to study the anxiety-performance relationship, and then research issues about

the facilitative/debilitative nature of competitive anxiety on sport performance will be addressed.

Drive theory

Drive theory was the first theoretical model to describe the anxiety/arousal-performance relationship in motor behavior. Based on Hull's (1952) behavioristic theory, Spence and Spence (1966) hypothesized that performance (P) is a multiplicative function of habit (H) and drive (D): $P = H \times D$. Habit refers to the hierarchical order or dominance of correct or incorrect response. Drive, on the other hand, is a concept related to arousal or anxiety (Jones, 1995). According to the drive theory, an increase in drive is related to an increase or a decrease in performance in a linear manner depending on the dominant response. For example, in the early state of learning (or performing a novel motor skill), the dominant response is incorrect and increases in arousal usually impair performance. Later in learning, when the dominant response is correct, increases in arousal usually enhance performance. Drive theory was used frequently in sport psychology as well as other psychology domains in earlier years to describe the positive linear relationship between arousal and performance. Zajonc (1965) studied the presence of an audience and its effect on one's learning and performing a task. His data were consistent with predictions of the drive theory. Oxendine (1970) also supported the drive theory for influencing performance in motor activities involving strength, endurance, and speed.

However, drive theory has been criticized by many researchers in sport psychology because it has several theoretical weaknesses and has not yielded consistent results in sport situations. In his review of research evidence, Martens (1974) asserted

that the drive theory hypothesis should be rejected since "it is not testable for motor behavior because of the inability to specify habit hierarchies for motor performance." Weinberg (1989), Parfitt, Jones, and Hardy (1990), and Hardy (1996) have also criticized the theory because it does not seem to reflect the complex nature of motor tasks, and is too simple to explain the relationship between anxiety/arousal and motor performance.

Due to insufficient empirical support and theoretical weaknesses, drive theory faded away in the sport psychology literature and in psychology in general. Instead, as an alternative, the inverted-U theory became a dominant theory.

Inverted-U theory

The inverted-U hypothesis originated from Yerkes and Dodson's work (1908) on the curvilinear relationship between arousal and performance in rats. Hypothesized was that performance would increase as arousal level increases until some optimal point. However, further increase in arousal (over the optimal point) would cause a decrease in performance. This hypothesis has been widely accepted by sport psychologists because it has intuitive appeal and has been supported (at least, partly) in many studies (Klavora, 1978; Martens, 1974, 1975; Martens & Landers, 1970; Weinberg & Regan, 1978).

Weinberg (1989) argued that the most plausible explanation for the inverted-U model could be Easterbrook's (1959) cue utilization hypothesis. Easterbrook proposed that increased arousal progressively restricts the detection of the range of cues available in one's external environment. Implicit in his hypothesis is a potential inverted-U relationship between arousal and performance based on a person's limited attentional capacity. Presumably, individuals under low levels of arousal have a broad perceptual range causing poor attentional selectivity of relevant/irrelevant cues to task, thus resulting

in low performance. As arousal increases to an optimal level, task-relevant cues are selectively attended to and task-irrelevant cues are eliminated. Therefore, maximum performance is achieved. However, increases in arousal beyond this optimal level lead to further attentional narrowing, with the elimination of task-relevant cues and subsequent poorer performance. Similar postulations have been made by Nideffer (1976, 1993). He proposed that increased arousal and state anxiety influence performance in sport activities due to changes in attention.

Recently, however, researchers have criticized the validity of the inverted-U hypothesis in sport contexts. The criticisms include: (a) the failure to explain why performance is impaired at arousal levels above and below the optimum (Eysenck, 1984; Landers, 1980); (b) the concern that it has only been applied to effects on general performance rather than specific effects on information processing efficiency (Eysenck, 1984); (c) that the shape of the curve has been questionable because once a performer is over-aroused, performance declines rather sharply, and there is great difficulty to regain optimum performance (Hardy, 1990, 1996; Hardy & Fazey, 1987); (d) that there is insufficient consideration for the cognitive requirements of different sport skills (Jones, 1990); and (f) that the theory has overlooked the multidimensional aspects of anxiety (Parfitt, Jones, & Hardy, 1990; Jones, Cale, & Kerwin,1989).

Though the inverted-U hypothesis has been criticized for these kinds of weakness, it is still a very important model to explain the relationship between anxiety/arousal and performance. It has significantly influenced more sophisticated developments in recent years, such as the multidimensional anxiety model and the cusp catastrophe model.

Multidimensional anxiety theory

One of the major weaknesses in the inverted-U hypothesis was that it did not account for the multidimensional nature of anxiety. Several researchers including Davidson and Schwartz (1976), Liebert and Morris (1967), and Martens (1987) have asserted that anxiety should be conceptualized as having state and trait components because these two components influence performance differently. Martens (1974, 1977, 1987) is credited for the concept and development of multidimensional anxiety theory considering the nature of competitive sport. Anxiety is conceptualized as a multidimensional construct involving cognitive anxiety and somatic anxiety.

Cognitive anxiety is defined as the cognitive element of anxiety, such as negative expectations and concern about the situation and potential consequences (Morris, Davis, & Hutchings, 1981). Somatic anxiety is supposed to be the physiological and affective component of anxiety directly reflecting autonomic arousal, such as tension and nervousness (Martens et al., 1990; Morris et al., 1981; Weinberg, 1989). Self-confidence is another component in the multidimensional model, but is not a direct measure of anxiety. However, a lack of self-confidence may cause cognitive anxiety (Martens et al., 1990). According to the theory, somatic anxiety, which is a conditioned response, has an inverted-U relationship with performance while cognitive anxiety is negatively related to performance (see Figure 2.1). Many investigations, including a series of study by Martens et al. (1990) and the other researchers using the CSAI-2 as a tool to assess the multiple components of anxiety have supported the basic assumption of the theory which differentiates each component of anxiety.

First, results have generally indicated that somatic anxiety increases sharply until competition begins and then decreases as competition progresses while cognitive anxiety remains relatively stable prior to competition (Burton, 1988; Martens et al., 1990; Wiggins, 1998). Second, other findings (Gould, Petchlikoff, Simon, & Vevera, 1987; Jones, Swain, & Cale, 1990) also have shown that cognitive anxiety and somatic anxiety have different antecedents. The antecedents of somatic anxiety mainly consist of conditioned responses to stimuli, such as pre-competition warm-up routines or fear of physical harm (Hardy, Jones, & Gould, 1996), while antecedents of cognitive anxiety are factors in the environment related to athletes' expectations of success, such as perception of one's own ability and that of an opponent. The multidimensional anxiety model has been tested in various sport settings and has been supported in many studies. For example, empirical documentation for the inverted-U relationship between somatic anxiety and performance has been demonstrated using pistol shooters (Gould, Petchlikoff, Simon, & Vevera, 1987), swimmers (Burton, 1988), hockey players (Jones & Cale, 1989), and basketball players (Parfitt & Hardy, 1987, 1993).

However, when considering the cognitive anxiety-performance relationship in sport, there may be limitations in the theory. Jones (1995) pointed out that findings have been equivocal with little evidence of the predicted relationship between cognitive anxiety and performance. Since the cognitive is concerned with the consequence of success or failure, the multidimensional theory predicts that cognitive anxiety is negatively related to performance. However, except for Burton's study (1988) using collegiate swimmers, other ones have not supported the predicted negative relationship. In many studies, such as one reported by Gould et al. (1987), no meaningful relationship

was observed between cognitive anxiety and performance. Furthermore, because self-confidence is regarded as the opposite of cognitive anxiety (Hardy, Jones, & Gould, 1996), the hypothesized positive relationship between self-confidence and performance has also been tested.

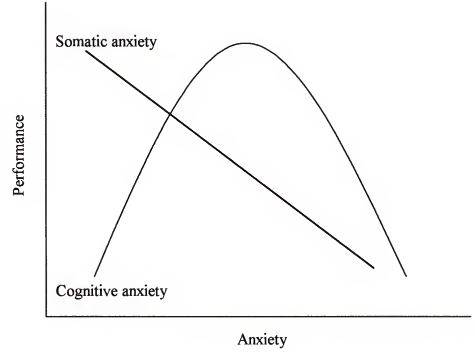

Figure 2.1. Multidimensional anxiety theory.

Results have not been conclusive and have indicated little evidence of the relationship (Gould et al., 1987; Hardy, Jones, & Gould, 1996; Jones, 1995; Martens et al., 1990).

In general, researchers have agreed that the strength of the multidimensional anxiety theory is in distinguishing anxiety components. However, insufficient support in its predictions has led to the development of more sophisticated and complex multidimensional models for describing the anxiety-performance relationship. Hardy (1996) and his associates have proposed a cusp catastrophe hypothesis. Based on catastrophe theory (Thom, 1975), which is a mathematical model to explain the physical world (waves in the sea), this hypothesis has been advanced to explain more precisely the interactive relationships among cognitive anxiety, physiological arousal, and performance. Hardy (1996) used the term, physiological arousal, in the model instead of somatic anxiety as a predictor variable. Unlike previous scholars, he attempted to model the interactive effects of cognitive anxiety and physiological arousal on performance, rather than to simply describe their separate effects.

Though Hardy (1996) claimed that a test of the cusp catastrophe model is possible with somatic anxiety, physiological arousal has been preferred in the model instead of somatic anxiety due to two different influence-mechanisms of physiological arousal on performance (Hardy, 1990, 1996; Hardy & Parfitt, 1991). According to Parfitt, Hardy, and Pates (1995), physiological arousal could directly influence performance through changes in the performer's activation state, and thus the availability of limited resources. Alternatively, it could also influence performance indirectly through one's positive or negative interpretation of perceived physiological symptoms. According to the cusp catastrophe model (Hardy, 1996), these interpretations are influenced by levels of

cognitive anxiety. Therefore, there is the possibility that physiological arousal may influence performance either directly or indirectly through interaction with cognitive anxiety. The use of somatic anxiety, on the other hand, may only indirectly influence performance (Hardy, 1996; Martens et al., 1990).

The cusp catastrophe model predicts that increases in cognitive anxiety will be beneficial to performance at low levels of physiological arousal, but detrimental to performance at high levels of physiological arousal (Hardy, 1996). Another prediction of the model is that at low levels of cognitive anxiety, changes in physiological arousal should have relatively small effects on performance in the manner of an inverted-U shape. However, at high levels of cognitive anxiety, the effects of physiological arousal could be either positive or negative relative to baseline performance, depending on the level of physiological arousal (Hardy, 1990). Furthermore, continued increases in physiological arousal would presumably eventually cause a sudden and dramatic drop in performance as the word "catastrophe" implies (see Figure 2.2).

Since not very many scholars have incorporated the cusp catastrophe model in their research so far, limited empirical evidence exists in such sport contexts as basketball (Hardy, & Parfitt, 1991), bowling (Hardy, Parfitt, & Pates, 1994), and softball (Krane, Joyce, & Rafeld, 1994). A more detailed discussion of the catastrophe theory has been reported elsewhere (Hardy, 1990, 1996).

Debilitative/facilitative competitive state anxiety in sport performance

One of the notions in the cusp catastrophe theory is that there can be facilitative effects of competitive state anxiety on sport performance.

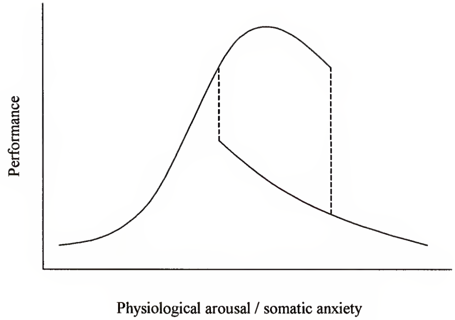

Figure 2.2. Predictions of cusp catastrophe model under high cognitive anxiety.

However, the idea of facilitative effects as well as debilitative effects related to anxiety is not new in cognitive psychology (Eysenck & Calvo, 1992). Several studies including Wine's (1980) bi-directional model of test anxiety have supported this notion. However, in sport psychology, the relationship between cognitive anxiety and performance has been viewed in a negative direction partly due to the fact that the concept of anxiety has largely been perceived as negative and detrimental to performance, and the CSAI-2, which is widely used by sport psychologists, merely measures the intensity of anxiety but not the direction of anxiety.

The concept of "direction of anxiety" refers to assessing how performers judge the cognitive and physiological symptoms they experience on a debilitative-facilitative continuum (Jones, 1995). One performer worrying too much about a forthcoming competition may experience a debilitative state negative to his/her performance. On the other hand, another performer, who is also very concerned about the competition, may regard such a state as necessary to remind him/her of its importance, and thus increase his/her effort. In this case, performance would be enhanced. Two different performers experiencing identical symptoms of anxiety could label those symptoms at completely opposite ends of the debilitative-facilitative continuum.

The distinction between intensity and direction of anxiety has been supported by several researchers. In a study using a modified version of CSAI-2, Jones and Swain (1992) found no differences in intensity of cognitive anxiety or somatic anxiety, or in direction of somatic anxiety, between high and low competitive groups. However, the highly competitive group reported its cognitive anxiety as more facilitative and less debilitative than did the low competitive group. Jones, Swain, and Hardy (1993)

investigated the relationship between intensity and direction of competitive state anxiety with regard to female gymnastic performance using the modified version of the CSAI-2. The results indicated no differences between good and poor performers in cognitive and somatic anxiety intensity scores, or in somatic anxiety direction scores. However, compared to poor performers, good performers reported that their cognitive anxiety was more facilitative and less debilitative. Another study, by Jones, Hanton, and Swain (1992), compared elite and non-elite swimmer groups and showed similar results. Despite no differences in the cognitive and somatic anxiety intensity between two groups, the elite performers interpreted both cognitive and somatic anxiety states as more facilitative than did non-elite performers.

The distinction between facilitative and debilitative anxiety has opened a promising area for further research in the competitive anxiety-performance relationship. Examined more thoroughly should be the mechanism via which anxiety subcomponents can have positive performance consequences (Hardy et al., 1996; Jones, 1995). Considered also should be individual difference factors (e.g., self-confidence), nature of the task (e.g., complexity, intensity, and duration), and perceived importance of a competition.

As to individual differences, Jones, Swain, & Hardy (1993) proposed that performers' directional interpretations of their anxiety symptoms may be predicted by positive-negative affects. They suggested that individuals high on negative affect consistently perceive their symptoms as debilitative, irrespective of intensity, and performers high on positive affect interpret them as more facilitative. According to Jones (1995), initial findings have supported this hypothesis. Another closely related variable

in the interpretation of anxiety direction may be self-confidence. Orbach (1998) recently investigated the relationship between self-confidence and facilitative/debilitative anxiety using the cusp-catastrophe model basis. She found that soccer players who experienced high cognitive and low somatic anxiety performed best only when they were self-confident. In general, the results supported previous findings, and indicated the importance of self-confidence as a moderator in the anxiety-performance relationship.

Jones et al. (1993) suggested that increased anxiety, until a certain optimal level, may enhance performance by increasing motivation and facilitating an appropriate attentional focus in some performers. In others, performance could deteriorate because limited available cognitive resources are wasted in task-irrelevant worry. Eysenck (1992, 1996) hypothesized that this facilitative effect of anxiety is a result of raised effort serving as a compensatory factor which increases the attentional resources allocated to performance. He argued that as anxiety reduces working memory capacity due to worry or task irrelevant cognitive activities, it diminishes processing efficiency. However, performance itself (or performance effectiveness) may be maintained, or even enhanced, under elevated anxiety conditions because this reduction in processing capacity could be countered by an increase in effort.

Eysenck's (1992) ideas, which are incorporated in processing efficiency theory, provided a very plausible mechanism to explain the facilitative/debilitative relationship between competitive anxiety and sport performance. Though a number of studies have addressed the processing efficiency theory in other fields of psychology, relatively few researchers in sport psychology have tested this model. Parfitt and Hardy (1993) used it to investigate basketball performance. Cognitive and somatic anxiety were manipulated

by a "time to event paradigm" (Martens et al., 1990), and performance was measured with a letter span (short-term memory) task and a rebound basketball shooting task (low memory demand, motoric-sustained information transfer task). They found a positive effect for cognitive anxiety on rebound shooting, and a negative effect for somatic anxiety on letter span. In general, the results were interpreted as partial support for Eysenck's processing efficiency model.

In summary, early studies in sport psychology concerned with the anxiety-performance relationship have been based on drive theory and the inverted-U theory. Although influence of these early theories are still of some interest, contemporary researchers advocate more sophisticated approaches such as multidimensional theory or the cusp catastrophe model. The multidimensional theory distinguishes multiple components of anxiety, and the cusp catastrophe model (Hardy, 1996) has attempted to describe the anxiety-performance relationship through the interaction between variables related to anxiety. Presumably, the relationship between competitive anxiety and performance does not have to be negative. It can be positive and facilitating or negative and debilitating, depending on various factors, such as individual differences, perceptions, and nature of the task. Among many factors, self-confidence appears to be important in interpreting anxiety in positive or negative way (Hardy et al., 1996; Orbach, 1998). Eysenck's (1992) processing efficiency theory was designed to offer an explanation of the effects of state anxiety on performance, especially as related to cognitive task performance. It could be a useful theoretical framework to investigate the relationship between competitive state anxiety and performance in sport science.

Obviously, many interesting and meaningful developments are occurring at the present time in an attempt to clarify arousal, anxiety, and performance relationships.

CHAPTER 3
METHODS

Participants

Forty two college male novice dart throwers served as volunteer participants in the experiment. The number of participants was determined with a power analysis software (Friendly, 1995). The values for entry for the sample size calculation were as follows: $\underline{a}$ = .05 (level of significance), r = 3 (level of the first factor), delta = .35 (effect size), and power = .8. Individuals who threw darts on more than five previous occasions during the past 10 years were excluded from the study.

In Experiment 1 (learning session), participants were randomly assigned to one of three groups (an external focus group, an internal focus group, and a control group). In Experiment 2 (performance session), members in each group were randomly divided and tested under a competitive condition or a non-competitive condition. No knowledge about the purposes of the study or hypotheses was provided to them. Additionally, they were informed that the objective in this experiment was to investigate the effects of the number of practice trials on dart throwing performance in order to conceal the real purposes.

Task

Instead of normal overhand dart throwing, underhand dart throwing served as a task in the study. It is somewhat novel, and has been used by a number of researchers (e.g., Epstein, 1980; Ko & Singer, 1999; Radlo, Steinberg, Singer, Barba, & Melnikov,

1999; Singer, DeFanscesco, & Randall, 1989) to investigate the influence of cognitive strategies on learning and performance.

Based on previous investigations (Ko & Singer, 1999; Radlo et al., 1999), in which the same task was used, the dartboard was located 10 cm higher than the official height (172.72 cm). This should have created a more novel situation than is associated with standard overhand tosses. Participants tossed the darts while standing behind a tossing line marked 364 cm from the target. This distance between the target board and the tossing line, which has also been reported in related studies (Ko & Singer, 1999; Radlo, 1997; Radlo et al., 1999), is 120 cm longer than the distance in official dart competition in England.

Apparatus

Dartboard and Dart

Standard competition darts weighing approximately 10g and 12cm long were used with a square dart board which had vertical and horizontal lines painted on the surface to form a score grid. Each line was separated 4.4 cm apart and numbered 1 through 10 (+ or – depending on the x, y coordination). A bull's eye, which was located in the center of the dart board, served as the primary target. The dart board hung from the ceiling approximately 183 cm above the floor, and a safety curtain was placed around the board as a safety precaution.

Eye Tracking System

Eye movement was measured with an infrared eye tracking system (ASL model 501 eye tracker and ASL model 5000 control unit). These data were recorded and processed by an IBM PC Pentium compatible that was interfaced with the tracking

system unit. A head mounted scene camera, which is an integrated part of ASL model 501 eye tracker, recorded the field of view as observed by the participants. An external video camera (HITACHI model VM-H825LA) recorded the movements of the participants during dart throwing. Visual orientation to the target was recorded simultaneously with action phases of the dart throwing act by the system unit and the external video camera.

Vision and Action Coupling

To effectively couple vision with action, the video signals from the two sources (the eye tracking system and the external video camera) were directed to a Videonix WJ-MX10 digital video signal mixer. The mixer created a split–screen effect. The higher right portion of the frame showed a participant performing the dart throwing act while the rest of the portion of the frame displayed eye gaze position data as recorded by the eye and scene cameras in the integrated eye tracker. This method of coupling vision and action has been used successfully by Adolphe and Vickers (1997), Frehlich (1997), Ko and Singer (1999), and Vickers (1996a, b), to show the strong relationship between visual control and motor performance. In this study, the method of coupling vision and action was used to measure QED.

LED Signal Indicator

During Experiments 1 and 2, a green colored LED was attached at the bottom of the dart board to signal the start of dart tossing.

Measures

Performance Measure

The dart throwing task required the computation of two-dimensional scores. For example, the best score (0, 0) was recorded when the dart hit the bull's eye (the center of the board), and a poor score (e.g., -12, 12) was recorded when the dart missed the target board completely. Scores from the x and y coordinates were converted to mean radial error (MRE), subject radial error (SRE), and bivariate variable error (BVE). Hancock, Butler, and Fischman (1995) have suggested that these measures are more appropriate for archery-type target tasks (two-dimensional) than traditional one-dimensional measurements such as absolute error (AE), absolute constant error (ACE), and variable error (VE).

MRE is a two-dimensional error score of overall accuracy in performance. This score, which is the 2D analog to absolute error (AE), indicates the degree to which a participant's tosses deviate from the desired target on the average. Thus, an analysis of variance on subjects' MRE scores answer questions about the accuracy of the shots group members (Hancock et al, 1995). SRE indicates the magnitude of bias over multiple trials from a single performer. This score is appropriate for answering questions about where, on the average, a performer's shots tend to be with respect to the center of the target, and considered as the 2D analog of absolute constant error (ACE). BVE refers to the measure of intra-subject variability for two-dimensional error. This score measures the inconsistency of responses, and is the 2D analog to variable error (VE). BVE scores directly answer the question of whether individuals in the different groups differed in their 2D performance consistency (Hancock et al., 1995).

Visual Attention Measure

Besides performance, a measure of interest in this study was quiet eye duration (QED). QED is defined as the period of time between onset of the final fixation to the target and the first observable movement of the hand holding a dart to execute the underhand throwing action. Each underhand dart toss was analyzed in a frame-by-frame manner, which had been used successfully by Frehlich (1997), Vickers (1996a, b), and Janelle et al. (1999), to calculate QED by a JVC S-VHS video recorder/player that had a built-in time counter and a jog-shuttle. Each frame constituted 33.3 ms of data, and based on previous studies (Frehlich, 1997; Ko & Singer, 1999; Ripoll, 1991; Vickers, 1992, 1996a, b), a fixation was defined as three or more consecutive frames (99.9 ms or more) where the cursor was located in the same space on the target in the visual environment.

Modified CSAI-2

A modified version of the Competitive State Anxiety Inventory - 2 (CSAI-2; Martens et al., 1990) was administered immediately prior to each experiment to obtain baseline data as well as to verify that participants in the competitive condition were sufficiently aroused in Experiment 2. The CSAI-2 is a multi-dimensional scale that has been shown to be a reliable and valid tool to measure cognitive anxiety, somatic anxiety, and self-confidence in sport specific contexts. This scale comprises 27 items, with 9 items in each of the three subscales of cognitive anxiety, somatic anxiety, and self-confidence. Responses to each item were in a Likert scale ranging from 1 (not at all) to 4 (very much so). Thus, scores could range from a low of 9 to a high of 36 for each of the three scales. The cognitive anxiety subscales were scored by totaling the responses for the following nine items: 1, 4, 7, 10, 13, 16, 19, 22, and 25. The somatic anxiety subscale

was scored by adding the responses to the following nine items: 2, 5, 8, 11, 14, 17, 20, 23, and 26. The self-confidence subscale was scored by adding the following items: 3, 6, 9, 15, 18, 21, 24, and 27. No total score for the inventory was calculated. The higher the score, the greater the cognitive anxiety, somatic anxiety, and self-confidence.

The inventory was modified (see Appendix A) to include a directional scale in which each participant rated the extent to which the experienced intensity of each symptom was either facilitative or debilitative to subsequent performance on a scale from –3 (very debilitative) to +3 (very facilitative) (Jones, 1995). Thus, the possible direction score on each subscale ranged from –27 to +27, with a negative score representing an overall negative (debilitating) perception and a positive score representing an overall positive (facilitating) perception of the symptoms in terms of their consequences for subsequent performance. In addition, the title on the CSAI-2 form was changed because it was recommended to do so in order to reduce response bias to the inventory.

Procedure

On arrival at the Motor Behavior Laboratory, all participants listened to a general description of the study and signed an informed consent form (see Appendix B). A demographic questionnaire (see Appendix D) was administered to obtain background information as to dart experience, and participants were screened accordingly.

Experiment 1 (learning session)

The primary purpose of this experiment was to investigate the influence of the two different attentional strategies on gaze behavior (e.g., QED) and performance while learning an underhand dart tossing task. Participants in the internal focus strategy group read standardized instructions individually about this strategy (see Appendix C), which

they attempted to apply while learning and performing the task. Written instructions about the internal focus strategy described how attention should be directed to sensations related to movements of his/her body during the act. Participants were told to be aware of the hand and arm movement during execution and dart release. Participants in the external focus strategy group learned with written instructions (see Appendix C) individually describing how to keep their focus on the target immediately prior to and while they were executing the toss. Those in the control group read about the history of dart game (see Appendix C). If participants had any questions during treatments, the experimenter answered them. All participants were allowed three practice attempts to familiarize themselves with the task. The amount of time (approximately 10 min) for treatments including reading instructions, asking questions, and attempting three dart tossing, was equal for each group.

To insure the use of the internal and external focus strategies by the appropriate groups during testing, participants were instructed to verbally state the name of their designated strategy prior to each practice trial. Additionally, the name of assigned strategy was posted in front of each person as a reminder. Afterward, the eye tracking system was mounted on the head of a participant, and initial calibration procedures were performed.

In Experiment 1, 48 underhand dart throws were executed, divided into 8 trial blocks with 8 tosses in each block. This number of trial blocks and trials was based on previous studies (Ko & Singer, 1999; Radlo, 1997; Radlo et al., 1999). A 40-sec break between trial blocks was provided. After participants completed the 64 tosses and filled out the modified CSAI-2 form, they took a 30-min break. Immediately before the

experiment began, the CSAI-2 were administered in order to record baseline anxiety data to compare against those recorded in Experiment 2, the competition session. Participants were allowed to leave the testing area to take a break, to use the bathroom, or to drink water. However, they were reminded when to return for Experiment 2, and any mental rehearsal of the task were discouraged.

Experiment 2 (competition session)

The primary purpose of this experiment was to investigate the influence of the two different attentional strategies on gaze behavior (e.g., QED) and performance while executing the underhand dart tossing task under a competitive or non-competitive condition. Participants were divided randomly into subgroups and tested under either condition. Those assigned to the competitive condition were told that their scores would be compared to the scores of others in the experiment, and that the best scorer would receive $100 in cash, the second best $60, and the third best $30. They were also informed that only seven persons in a group would compete, and that they were one of the last tossers. They were notified about the results of their performance (i.e., whether they finished in the top three) and that payment would be made after all individuals completed the experiment.

Everyone was given 32 attempts (4 trial blocks of 8 tosses each) to assess retention of the skill as well as the influence of competition. They were asked to complete the CSAI-2 again prior to the experiment to measure anxiety. A post-test questionnaire (open-ended questions scripted with a 10-point Likert scale) assessing strategy use was also administered at the end of the experiment.

Experimental Design

The design of Experiment 1 was a 3 x 8 (attentional strategy x trial block) factorial, with repeated measures on the second factor, and the design of Experiment 2 was a 3 x 2 x 4 (attentional strategy x competition x trial block) factorial, with repeated measures on the last factor. A summary of the design of the study is presented in Table 3.1.

Table 3.1

Design of the Study

	Experiment 1: Learning		**Experiment 2: Retention**
	Trial Blocks		Trial Blocks
External Strategy	1 2 3 4 5 6 7 8	**Competition**	1 2 3 4
		Non-competition	1 2 3 4
Internal Strategy	1 2 3 4 5 6 7 8	**Competition**	1 2 3 4
		Non-competition	1 2 3 4
Control	1 2 3 4 5 6 7 8	**Competition**	1 2 3 4
		Non-competition	1 2 3 4

CHAPTER 4
RESULTS

The primary emphasis in the two experiments was to investigate the influence of two independent variables (attentional strategy and competitive anxiety) on dart performance and quiet eye duration. Dart performance data were analyzed with a MANOVA rather than ANOVA because MANOVA is more robust to violation of statistical assumptions (Davidson, 1972), provides greater control over a Type I error (Schutz & Gessaroli, 1987), and is more appropriate for the related nature of the dependent performance measure: MRE, SRE, and BVE. ANOVAs and MANOVAs were used to analyze subscales in the modified CSAI-2 as well as visual gaze data (QED).

Alpha was set at the .05 level for all statistical analyses. The Wilk's Lambda was the MANOVA test selected in this study. ANOVAs were conducted as follow-up tests, as appropriate. When violations of sphericity assumptions were found, Greenhouse-Geisser (Greenhouse & Geisser, 1959) adjustments were applied to control for Type I errors. Therefore, some data in the Result's section, such as degrees of freedom, are adjusted values according to the Greenhouse-Geisser test. Tukey's post-hoc test as well as simple effects tests were used for final data analysis, if relevant. In addition to results of analyses presented in this chapter, results of descriptive statistics for performance and CSAI-2 are also presented in Appendix F.

Performance

Doubly Multivariate (DM) Analysis of MANOVA (SPSS, 1999), which has been recommended by Schutz and Gessaroli (1987) for a repeated measure design, was used to analyze performance scores (MRE, SRE, and BVE). These scores represented overall accuracy of shots (MRE), overall consistency (SRE) (the magnitude of bias over multiple shots with respect to the center of the target for each participant), and overall variability (BVE) among each shot. These measures are error scores; thus lower scores indicate better scores.

A 3 x 8 (strategy x trial block) MANOVA with repeated measures on the second factor and a 3 x 2 x 4 (strategy x competition x trial block) MANOVA with repeated measures on the last factor were conducted in Experiment 1 and Experiment 2, respectively.

In Experiment 1, MANOVA revealed a significant main effect for trial block, F (21, 19) = 6.34, $p < .001$. The analysis conducted on MRE scores indicated a significant main effect for trial block, F (7, 5.16) = 11.54, $p < .001$. Further analysis of MRE scores with the Tukey's HSD test revealed that overall accuracy of dart performance for strategy groups when combined improved (i.e., lower MRE scores) significantly across trial blocks in Experiment 1 (see Figure 4.1). Specifically, significant differences in MRE scores were found between trial blocks 1 and 3; 1 and 4; 1 and 5; 1 and 6; 1 and 7; 1 and 8; 2 and 5; 2 and 6; 2 and 7; 2 and 8.

The analysis conducted on SRE scores indicated a significant main effect for trial block, F (7, 4.36) = 7.89, $p < .001$. Further analysis of SRE scores with the Tukey's HSD test revealed that overall consistency of dart performance with the three groups combined

improved (i.e., lower SRE scores) significantly across trial blocks (see Figure 4.2). Specifically, significant differences in SRE scores were found between trial blocks 1 and 3; 1 and 4; 1 and 5; 1 and 6; 1 and 7; 1 and 8; 2 and 8.

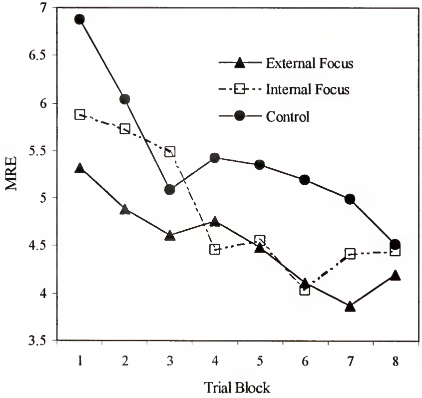

Figure 4.1. Mean radial error (MRE) scores for groups across trial blocks in Experiment 1.

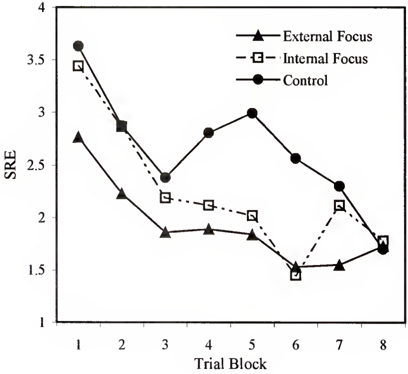

Figure 4.2. Subject-radial error (SRE) scores for groups across trial blocks in Experiment 1.

Analysis of BVE scores also indicated a significant main effect for trial block, F (7, 5.77) = 5.47, $p < .001$. Further analysis of BVE scores with the Tukey's HSD test revealed that overall variability of dart performance improved (i.e., lower BVE scores) across trial blocks (see Figure 4.3). Specifically, significant differences in BVE scores were found between trial blocks 1 and 6; 1 and 7; 1 and 8; 2 and 6; 2 and 7. As reflected in the analysis of MRE, SRE, and BVE scores, overall dart performance in terms of accuracy, consistency, and variability in the three groups, when combined, significantly improved over trials in Experiment 1.

In Experiment 2, the 3 x 2 x 4 (strategy group x competition x trial block) MANOVA yielded a significant main effect for trial block, F (9, 28) = 3.20, $p < .009$. In addition, and more importantly, a significant strategy group x trial block interaction effect was found, F (18, 56) = 2.10, $p < .018$. A follow-up ANOVA conducted on MRE scores indicated a significant main effect for trial block, F (2.42, 87.11) = 4.96, $p < .006$. Further analysis with the Tukey's HSD test revealed a significant difference in MRE scores for the combined three groups between trial block 1 and 3, with trial block 3 producing more accurate scores. The ANOVA conducted on BVE scores indicated a significant main effect for trial block, F (2.5, 90) = 6.25, $p < .001$, and a significant strategy group x trial block interaction, F (5, 90) = 2.52, $p < .035$. Inspection of this two-way interaction (see Figure 4.4) with simple effects tests and Tukey's post-hoc tests revealed that the external focus strategy group and the internal focus strategy group had better performance in terms of less variability (less BVE score) than the control group.

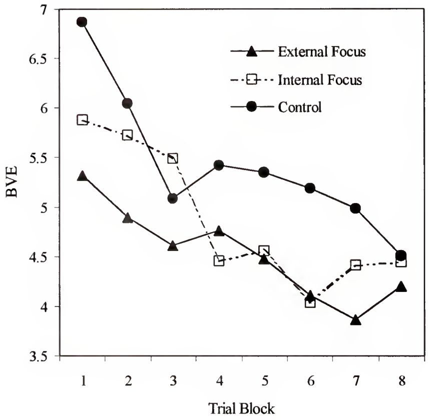

Figure 4.3. Bivariate variable error (BVE) scores for groups across trial blocks in Experiment 1.

Specifically, there was a significant difference in BVE scores for the combined competition/non-competition conditions between the external focus strategy groups and the control groups at trial block 1, and between the internal focus strategy groups and the control groups at trial blocks 1 and 4. In other word, participants, used the external focus strategy or the internal focus strategy, performed better with less variability than those who did not use any particular strategy. On overall, participants performed better (with lower MRE, SRE, and BVE scores) in Experiment 2 than in Experiment 1 (see Table 4.1).

Table 4.1

Performance Scores in Experiments 1 and 2

Measure	Experiment	M	SD
MRE	1	4.967	.150
	2	4.385	.143
SRE	1	2.283	.117
	2	1.889	.115
BVE	1	4.936	.162
	2	4.419	.142

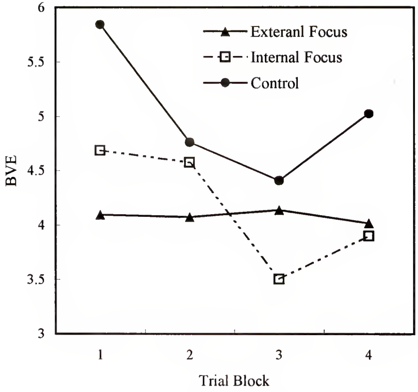

Figure 4.4. Strategy group x trial block interaction for BVE scores in Experiment 2.

Quiet Eye Duration

To analyze QED measures during Experiments 1 and 2, a 3 x 8 (strategy x trial block) ANOVA with repeated measures on the second factor and a 3 x 2 x 4 (strategy x competition x trial block) ANOVA with repeated measures on the last factor were conducted, respectively.

In Experiment 1, the ANOVA test indicated a significant main effect for strategy, F (2, 39) = 16.23, $p < .000$ (see Figure 4.5). Further examination with the Tukey test revealed that the external focus strategy group had much longer QEDs (M = 1524.96, SD = 920.74) than the internal focus group (M = 552.30, SD = 256.85) and the control group (M = 537.75, SD = 225.89).

In Experiment 2, the ANOVA test yielded a significant main effect for strategy, F (2, 144) = 52.49, $p <= .000$, for competition, F (1, 144) = 19.38, $p < .001$, and for a strategy x competition interaction effect, F (2, 144) = 17.32, $p < .001$. The strategy x competition interaction is shown in Figure 4.6. Inspection of this interaction (see Figure 4.6) with simple effects tests revealed that the differences of QED between the external focus strategy group and the other two groups under the non-competition condition became even greater under the competition condition. Tukey's HSD tests supported this inspection by indicating that the external focus strategy group had a significantly longer QED than the other two groups during the non-competition condition as well as the competition condition. These tests also revealed that only for the external focus strategy there was a significant difference in QED between the competition condition (longer QED) and the non-competition condition (shorter QED). For the internal focus strategy

and control groups, there was no significant difference in QED between the competition condition and the non-competition condition.

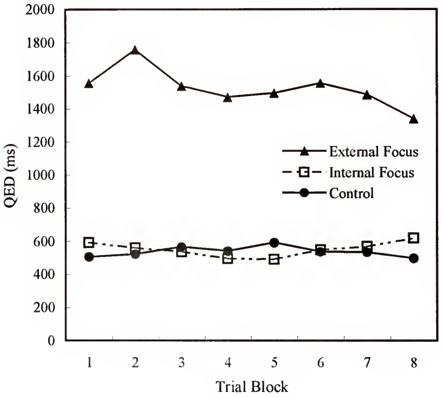

Figure 4.5. QED scores for strategy groups across trial blocks in Experiment 1.

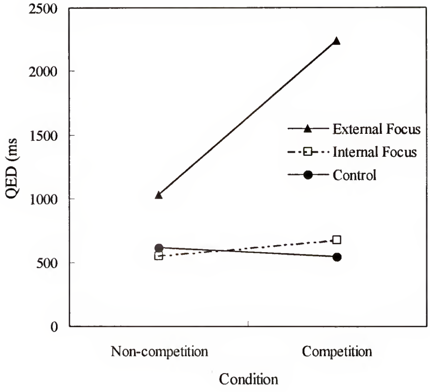

Figure 4.6. Strategy x competition interaction for QED in Experiment 2.

CSAI-2 Scores

To analyze the four sub-scales of the modified CSAI-2 (cognitive anxiety, somatic anxiety, self-confidence, and direction of anxiety), a 3 x 2 x 2 (strategy x competition x experiment) MANOVA with repeated measures on the last factor was conducted. The competition x experiment interaction was significant, $F(4, 33) = 4.38$, $p < .006$. Follow-up univariate F-tests for each subscale indicated that the competition x experiment interaction was significant for cognitive anxiety, $F(1, 36) = 9.75$, $p < .004$, somatic anxiety, $F(1, 36) = 8.22$, $p < .007$, and self-confidence, $F(1, 36) = 8.92$, $p < .005$. Inspection of interaction (Figures 4.7, 4.8, and 4.9) indicated the effects of the anxiety manipulation (i.e., monetary incentives). Cognitive anxiety in the competition groups increased from Experiment 1 ($M = 13.19$, $SD = 3.88$) to Experiment 2 ($M = 15.24$, $SD = 5.80$). On the contrary, however, the non-competition groups reported decreased cognitive anxiety scores from Experiment 1 ($M = 14.48$, $SD = 3.25$) to Experiment 2 ($M = 12.71$, $SD = 3.54$) (see Figure 4.7). This trend (the direction of the interaction) was the same for somatic anxiety (see Figure 4.8 and Table 4.2). For the self-confidence subscale, participants in the competition groups reported decreased self-confidence from Experiment 1 to Experiment 2. However, participants in the non-competition groups reported increased self-confidence from Experiment 1 to Experiment 2 (see Table 4.2 and Figure 4.9). Simple effect tests conducted for the competition x experiment interaction revealed that for the somatic anxiety, the participants in the competition condition rated themselves higher ($M = 24.14$, $SD = 4.61$) than the participants in the non-competition condition ($M = 22.29$, $SD = 5.62$).

The positive means of the direction of anxiety data (see Table 4.2) indicated that participants in both competition condition and non-competition condition interpreted anxiety symptoms as relatively facilitative.

Table 4.2

CSAI - 2 Subscale Measures in Experiments 1 and 2

Subscale	Condition	Experiment	M	SD
Cognitive	Competition	1	13.19	3.88
		2	15.24	5.80
	Non-competition	1	14.48	3.25
		2	12.71	3.54
Somatic	Competition	1	13.57	2.96
		2	15.91	4.98
	Non-competition	1	14.38	3.22
		2	13.00	3.10
Self-confidence	Competition	1	24.14	4.61
		2	22.05	5.54
	Non-competition	1	22.29	5.62
		2	23.76	7.06
Direction of Anxiety	Competition	1	24.14	21.62
		2	25.10	27.15
	Non-competition	1	17.57	18.42
		2	17.33	20.09

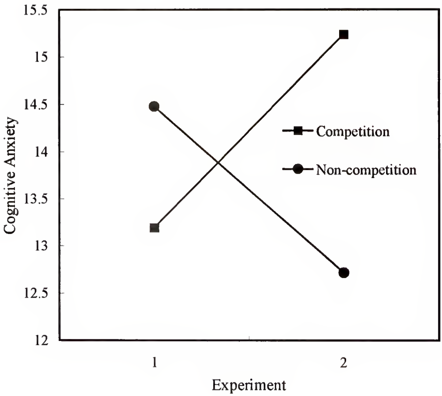

Figure 4.7. Competition x experiment interaction for the cognitive anxiety subscale in the CSAI–2.

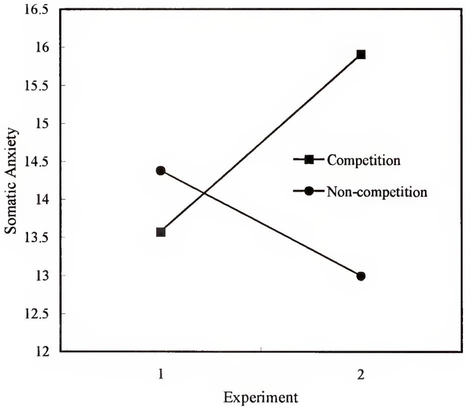

Figure 4.8. Competition x experiment interaction for the somatic anxiety subscale in the CSAI – 2.

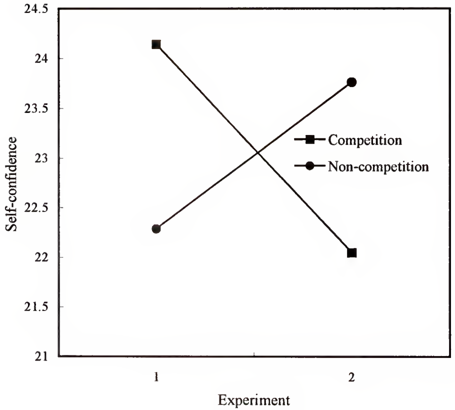

Figure 4.9. Competition x experiment interaction for the self-confidence subscale in the CSAI – 2.

Manipulation Checks

A post-test questionnaire was administered to all participants at the end of Experiment 2 to check strategy use in Experiments 1 and 2. The questionnaire included one yes/no question, one open-ended question (see Appendix E), and two 10-point likert scale questions rated from 0 % to 100 % to assess what percentage of trials the participants believed that they used a specific focus strategy (i.e., external focus or internal focus) during the testing. All the participants in the external focus strategy groups and the internal focus strategy groups identified the name and use of their assigned strategies (external focus or internal focus) for Experiments 1 and 2. Participants in each group reported that they used their assigned strategies over 90 % of the trials during Experiments 1 and 2. Among the participants in the control groups, only two of them reported that they used a kind of external focus strategy and imagery during the experiments to help their performance. The others reported no use of any particular strategy.

CHAPTER 5
DISCUSSION, SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FUTURE STUDY

Two experiments were conducted to further an understanding of the influence of two kinds of attentional strategies as well as competitive anxiety on visual attention and performance in a self-paced aiming task, underhand dart throwing. Several questions related to strategy, visual attention, competitive anxiety, and performance were addressed in a sport psychology/motor learning context.

Specifically, an attempt was made to determine whether an external focus strategy or an internal focus strategy was more effective for learning and performing the task. Second, of interest was the influence of an attentional focusing strategy (e.g., external or internal) on quiet eye duration (QED). Third, a monetary competitive incentive condition was introduced to determine effects on performance and visual attention behavior. Finally, an attempt was made to examine relationships between attentional focusing strategy and competitive anxiety components (cognitive anxiety, somatic anxiety, self-confidence, and positive or negative direction of anxiety) with regard to performance.

In this chapter, hypotheses related to each experiment are discussed, and results are explained in the context of relevant theories and relevant research. A general summary section and a conclusion section are provided next. Application of the results and potential further research are presented in the last section.

Experiment 1

The purpose of Experiment 1 was to investigate the effect of two different attentional focusing strategies (external and internal) on dart performance and quiet eye duration. Performance was measured by mean radial error (MRE), subject-centroid radial error (SRE), and bivariate variable error (BVE). Data in Experiment 1 supported one of the hypotheses proposed in the chapter 1. Among the seven hypotheses that were presented, three hypotheses were specifically related to Experiment 1.

Hypotheses Related to Performance

Two specific hypotheses were generated relative to performance outcomes. First, it was expected that the external focus strategy group and the internal focus group would record lower MRE scores, SRE scores, and BVE scores than the control group while learning the task. In other words, the beneficial effects of the two attentional strategies on performance would be shown to lead to more accuracy, more consistency, and less variability in dart performance. Second, it was expected that the MRE, SRE, and BVE scores of the external focus strategy group would be better (less) than those of the internal focus strategy group. However, these two hypotheses were not supported.

Results from a number of studies (i.e., Lidor, 1991; Radlo, Steinberg, Singer, Barba, & Melnikov, 1999; Singer & Lidor, 1993; Singer, Lidor, & Cauraugh, 1994) have indicated superiority of an external focus strategy over the internal focus strategy for learning self-paced tasks as well as performance advantage of the two strategies (internal and external focus) compared with a non-designated strategy. However, in the present study, there were no significant diffrences between the two attentional strategy groups or with the control (non-strategy) group for performance improvement regarding MRE, SRE,

and BVE scores. The three groups improved performance over trials in Experiment 1. Two recent studies (Lidor, Tennant, & Singer, 1996; Ko & Singer, 1999) also yielded results that are in concordance with the data in the present study.

For example, when Lidor et al. (1996) examined effects of three learning strategies (awareness, nonawareness, and Five-Step strategy) on overhand ball tossing and underhand dart tossing tasks, participants who used an awareness (in other words, internal focus) strategy or an nonawareness (in other words, external focus) strategy did not lead to better performance in comparison with those in the control group. Furthermore, the external focus strategy group did not demonstrate a performance advantage over the internal focus strategy group. The researchers attributed the inconsistency of results in their investigation with other investigations to differences in participant numbers, differences in trial numbers, and individual variance in rate of skill acquisition. Perhaps this was the case in the present study. Another reason for this inconsistency in results of certain studies including the present one, could be the relatively small enhancement effect of these two strategies on performance. Because only the Five-Step strategy, which has both external and internal focus strategy components, showed performance advantage over the other strategies (external focus, internal focus, and non-strategy) in the Lidor et al. (1996) study, the authors suggested that external and internal focus strategies alone might not be sufficient enough for learning and performance enhancement.

Another concern about inconsistency in research is the number of practice trials administered in different investigations. Sport psychologists have indicated that appropriate visual attention and focus is conductive to productive performance (Weinberg

& Gould, 1999). Especially in self-paced aiming-type tasks, such as dart throwing, use of an external focus strategy (focus on the target) immediately prior to and during the act should be very beneficial to performance. However, several researchers (i.e., Lidor, 1999; Lidor, Tennant, & Singer, 1996; Masters, 1992; Singer, 1988) have suggested that much practice is necessary to use this strategy effectively. In a fine motor skill such as dart throwing, to orient attention exclusively and conciously on a target immediately prior to and during execution could be difficult because of distracting thoughts and an inability to concentrate continuously. Therefore, to observe the beneficial effect of an external attention strategy on performance, an extended amount of practice is probably necessary. Earlier investigations (Singer et al., 1993, 1994) that showed a significant performance advantage of an external focus strategy included relatively more practice trials and more subjects than was the case with the present study and other recent studies (Ko & Singer, 1999; Lidor et al., 1996).

Hypotheses Related to Visual Attention

During dart tossing, the external focus strategy group was expected to demonstrate longer quiet eye durations (QED) than the internal focus strategy group and the control group. Data in Experiment 1 clearly supported this hypothesis. During Experiment 1, participants who used the external focus strategy while performing the task had a significantly longer QED compared to participants who used the internal focus strategy and those who did not use any particular strategy (the control group). Furthermore, there was no significant difference in QED between the internal focus strategy group and the non-strategy (control) group.

QED is supposed to be a critical period of cognitive programming required to aim to a target successfully (Vickers et al., 2000), and thus could provide evidence for a strong eye-mind connection. Based on this assumption, Frehlich (1997) suggested that QED could be an index to indicate the effective visual gaze strategy of highly skilled performers. Many studies (e.g., Janelle, Hillman, Apparies, & Hatfield, 2000; Janelle, Hillman, Apparies, Murray, Meili, Fallon, & Hatfield, 2000; Ripoll, Bard, & Paillard, 1986; Ripoll, Papin, Guezennec, Verdy, & Philip, 1985; Vickers, 1992) have demonstrated that experts usually use a more effective and systematic selective attentional focus before and during the performance of self-paced motor skills. These visual attentional characteristics of experts may be acquired by beginners, if they learn and use an appropriate attentional strategy. Ko and Singer (1998, 1999) as well as other researchers (Lidor, 1999; Singer et al., 1993, 1994; Wulf & Weigelt, 1997, Wulf, Hoss, & Prinz, 1998) have proposed attentional focusing strategies for demonstrating skill in self-paced, target-aiming tasks. It appears that an external focus strategy is related to a longer gaze as measured by the QED. Analysis of the data in Experiment 1 revealed that the external focus strategy influenced the duration of QED to a great extent. However, the internal focus strategy did not.

In the present study, however, the external focus strategy, which significantly increased QED, did not show any performance advantage over the internal focus strategy and non-designated strategy (control group) in Experiment 1. The internal focus strategy, which did not significantly increase QED, also did not show a performance advantage over non-designated strategy (control group). When comparing the conflicting results in this study with those in several previous studies that showed positive effects of

attentional strategies on performance, there is possibility that the participants in the two strategy groups might not understand the strategies thoroughly, and thus the positive effects of the strategies on performance would be smaller than expected. In addition, the results in Experiment 1 also suggested that the presumed relationship between QED and performance: the longer QED, the better performance (Frehlich, 1997), may not be true.

Experiment 2

The main purpose of Experiment 2 was to investigate the effect of competitive anxiety on performance and on quiet eye duration (as assessed with MRE, SRE, and BVE scores) in the underhand dart task. The three hypotheses established for Experiment 1 were also applied to Experiment 2 under the competition and non-competition conditions of Experiment 2. Data in Experiment 2 supported several of the hypotheses. Among the seven hypotheses that were presented in Chapter 1, four hypotheses were specifically related to Experiment 2. Hypotheses about the interaction between the two manipulations (attentional focusing strategy and competitive anxiety) and their effect on QED and performance are also included in the last part of this section.

Hypotheses Related to Performance

As in the first experiment, two general hypotheses were generated relative to performance outcome for the attentional strategy manipulation. In addition, one specific hypothesis was proposed relative to performance outcome under the competitive anxiety manipulation.

First, participants in the two attentional focus strategy groups were proposed to exhibit more skill than those in the control groups under the competition condition and the non-competition condition. Unlike the results from Experiment 1, data from

Experiment 2 partly supported this hypothesis. The external and internal strategy groups demonstrated better skill in terms of lower variability in performance than the control group. This result is supported by previous research, such as Lidor (1991), Singer et al. (1993, 1994), and Radlo et al. (1999). Second, the external focus strategy groups were expected to be more successful than the internal strategy groups under the competition condition and non-competition condition. The data did not support this hypothesis. The performance advantage of an external focus strategy over an internal focus strategy was not confirmed in Experiment 2, and a few studies (Lidor et al., 1996; Ko & Singer 1999) have shown inconsistent results in this area. However, many studies, especially including Wulf and her colleagues' work (e.g., Wulf, Hoss, & Prinz, 1998; Wulf, Lauterbach, & Toole, 1999; Wulf, Shea, & Whitacre, 1998; Wulf & Weigelt, 1997) have supported a performance advantage of an external focus strategy over an internal focus strategy.

Third, all groups in the competition condition were expected to demonstrate better performance (i.e., lower MRE, SRE, and BVE scores) than groups in the non-competition condition. The data did not support this hypothesis, which was based on the cusp catastrophe model (Hardy, 1996). The model describes the interactive effects of cognitive anxiety and physiological arousal/somatic anxiety. According to the cusp catastrophe model, increments in physiological arousal/somatic anxiety will influence performance positively until a certain optimal level, while cognitive anxiety is high. However, a further increase of physiological arousal/somatic anxiety may cause a sudden drop in performance. In Experiment 2, it was expected that the induced higher level of cognitive and somatic anxiety (which should not be too high but moderately higher than the anxiety level of non-competitive groups) should affect performance positively Data

from Experiment 2 did not show any significant performance difference between the competition condition and the non-competition condition.

The research design in Experiment 2 did not comply exactly with the original cusp catastrophe model proposed by Hardy (1990). Instead of somatic anxiety, physiological arousal was included as a mediator factor for performance variation in Hardy's original cusp catastrophe model. Although Hardy (1996) suggested later that somatic anxiety is an alternative of physiological arousal in the model, it would still be a weak factor in the Experiment 2 design to support the catastrophe model. In addition, to investigate the catastrophe model in a more stringent way, levels of somatic and cognitive anxiety should be manipulated with an appropriate method, such as the "time to event paradigm" to observe potential changes in the components of anxiety (for more information, see Hardy, 1996). In the present study, strong support for the catastrophe model was not of primary interest, though the model was proposed in the introduction of this study to be used in explaining the data in the experiments.

Considering other studies and literature (e.g., Nideffer, 1993; Nideffer & Sagal, 1998; Radlo et al., 1999; Rotella & Lerner, 1993) which have indicated the positive influence of cognitive strategies on achievement in self-paced motor skills, participants in the external and the internal focus strategy groups might be expected to perform better than those in a control group. Results from Experiment 2 showed stronger support for this possibility than did Experiment 1. In Experiment 2, participants in both strategy groups (external and internal focus) performed better with less variability, compared with those in the control group, and this result is compatible to previous research (Lidor, 1991; Singer et al., 1993, 1994; Ko & Singer 1999).

Hypotheses Related to Visual Attention

Participants performed in the competition condition were hypothesized to demonstrate longer quiet eye durations (QED) than those in the non-competition condition. In addition, it was also expected that the external focus strategy groups would demonstrate longer QEDs under both competitive and non-competitive conditions than the internal focus strategy groups and the control groups. The data partly supported these two hypotheses. The external focus strategy group had a significantly longer QED than the other two groups (internal focus strategy and control) under non-competition condition, and this QED difference was even greater under competition condition. In other words, a competition condition leads to significantly longer QEDs throughout the trials for participants who used the external focus strategy. However, the internal focus strategy groups and the control groups demonstrated similar QED recordings in the competition condition as well as in the non-competition condition.

Among the several potential explanations for an increase in QED under a competition condition, the most plausible one was suggested by Eysenck and his colleagues. According to processing efficiency theory (Eysenck & Calvo, 1992), although increased level of anxiety (especially cognitive anxiety) may reduce attentional resources available for performing motor tasks, it may also motivate increased attention in a desirable way to a target task. These increased efforts to attend could result in changes in visual attention behaviors, such as measured by the QED. Therefore, increased anxiety, caused by the competition condition, would positively influence the duration of quiet eye. In the other words, a more ideal (longer) QED should occur.

Additionally, an increase in QED as related to the external focus strategy should occur because the strategy instruction emphasized intentional visual focus on the target.

Data in Experiment 2 indicated that the influence of external focus strategy on a longer QED was especially noted in the competition condition. This result could be explained by processing efficiency theory in that there was a synergy effect of the external focus strategy and increased attention under higher competitive anxiety.

Hypotheses Related to Anxiety

First, it was hypothesized that participants who performed the dart tossing task under the competitive condition would demonstrate higher cognitive and somatic anxiety scores, measured by the modified CSAI–2, than participants who performed under the non-competitive condition. Second, the two strategy groups (external and internal focus) that experienced competition were expected to demonstrate different anxiety profiles (cognitive anxiety, somatic anxiety, confidence, and perceived direction of anxiety symptoms) compared to those in the non-strategy (control) group. Between these two hypotheses, the first one was clearly supported by the CSAI-2 data from Experiments 1 and 2. Numerous studies (Fowler, Fisher, & Tranel, 1982; Radlo, 1997; Tranel, Fisher, & Fowler, 1982) investigating competition anxiety have shown that a monetary incentive positively increases competitive anxiety sub-components (i.e., somatic and cognitive). The results of this study also supported the outcome of previous investigations. Among the four subscales of the CSAI–2, for the somatic anxiety measure especially, the difference between participants in the competition condition and in the non-competition condition was significant. Contrary to somatic and cognitive anxiety measurements, analysis indicated that self-confidence decreased under the competition condition.

Positive scores for the direction of the competitive anxiety data could be interpreted that participants who performed in both competition and non-competition conditions interpreted anxiety symptoms as relatively facilitative.

The second hypothesis was not supported. Data from the CSAI–2 showed no significant interaction between strategy and competition as well as no significant differences between strategy groups. Under competition and non-competition conditions, the participants in the three attentional strategy groups demonstrated almost identical anxiety profiles for each of the subscales of CSAI–2 (cognitive anxiety, somatic anxiety, confidence, and perceived direction of anxiety symptoms). The effects of attentional strategies on anxiety components (e.g., somatic and cognitive anxiety) have been rarely studied under competitive conditions. Research (Chen & Singer, 1992; Ko & Singer, 1998, 1999; Lidor, 1999; Nideffer, 1993; Nideffer & Sagal, 1998; Radlo et al., 1999; Singer, 1988; Singer, Cauraugh, Tennant, Murphey, Chen, & Lidor, 1991) has suggested that an appropriate cognitive strategy may help in optimizing performance under anxiety conditions, thereby having a positive influence on performance. However, the influence of a particular attentional strategy on competitive anxiety and in turn on performance needs more investigation. Some trends in the data in this study implied that the external focus strategy might help performers to exhibit different anxiety profiles (i.e., less cognitive and somatic anxiety, higher self-confidence, and more positive direction for anxiety symptoms). However, these trends were not statistically significant. To better understand the relationship between particular attentional strategies and competitive anxiety, further research is needed.

Results from Experiment 2 suggested that QED can be increased by an external focus strategy, especially in a competitive condition. However, this increase in QED did not lead to increase in performance. Although two attentional strategy groups (external and internal) demonstrated better performance in terms of variability than the control group, and QED of the external strategy group was significantly longer than that of the internal strategy group, the performance of these two groups was indistinguishable. When considering results from previous studies (e.g., Adolphe et al., 1997; Frehlich, 1997; Vickers, 1992, 1996a, b; Vickers & Adolphe, 1997, 1998) that showed a positive relationship between QED and performance in far target aiming tasks, the results of the present study were somewhat surprising. QED is perhaps one of the important factors that contribute to increase in performance. However, data in this study did not support data from previous research. So far no researcher has tried to measure the direct relationship between QED and performance in each trial by using a correlation analysis. To confirm the relationship of QED to performance, further study examining the correlation between QED and performance is needed. Indeed, there is probably an optimal time for QED to be allocated to a target, and not the notion that longer is always better in order to execute a task successfully.

In general, influence of an external focus strategy, which caused an increase in QED, did not lead to an enhancement in learning and performance in this study. However, several studies (e.g., Wulf et al., 1998, 1999) have demonstrated a positive influence of an external focus strategy on performance, and other studies (e.g., Frehlich, 1997; Vickers, 1996a), which investigated QED under the expert vs. non-expert paradigm, have suggested that a longer QED seems to be a characteristic of an expert performer. If

it is assumed that QED is an index for differentiating experts from non-experts, but that a longer QED does not necessarily guarantee better performance, the inconsistency of results between previous studies and the present one may be explained due to misunderstanding and misuse of the attentional strategies on the part of the participants in the present investigation. In the present study, participants who used an attentional focus strategy (internal or external) might not have completely understood their strategy and thus, only superficially used the strategy. For example, superficial application of an external focus strategy might result in a longer QED, as in the present experiment, because the strategy instructions emphasized consistent focusing on the target. However, influence of the strategy on performance might be very minimal because the participants did not quite understand and activate the internal processes related to an external focus strategy. For example, it is possible that experts use the quiet eye period to preprogram the movement, become focused, and self-regulate thoughts and emotions. Perhaps this did not occur in the present study because the learners were not sophisticated enough to function at that level.

Although strategy usage in this study was checked with verbal reports, this procedure may have been too superficial. Teaching a strategy in the same way that it might benefit an expert could be very time consuming and require a fair amount of experience on the part of the learners with regard to the task and use of the strategy. Furthermore, making sure of the appropriate use and understanding of the strategy is not easy. In order to determine greater potential positive effects of strategy use, experimenters need to explore better usage of introducing a strategy as well as how to evaluate its' utilization in a learning and/or performing situation.

Summary

There were two primary purposes in this study. First, the intent was to investigate the influence of two different attentional strategies on quiet eye duration (QED) as well as on performance of an underhand dart tossing task. A second purpose was to investigate the influence of competitive anxiety on quiet eye duration as well as on the performance of the task. In addition, the interaction of attentional strategy, competitive anxiety, QED, and performance, was of interest. QED was defined as final fixation time on the target with onset prior to the final throw (Vickers 1996a).

Two experiments were conducted. In Experiment 1, 42 males recruited from classes at a large university, were randomly assigned to one of three groups (external focus strategy, internal focus strategy, or control) and then they performed 64 trials in an underhand dart tossing task. In Experiment 2, the three groups performed 32 trials with the same task in either a competition condition or a non-competition condition. Monetary incentive was added to the competition condition. MRE, SRE, and BVE measures, derived from the performance scores, as well as QED measures, were determined in Experiments 1 and 2. To measure state anxiety level, the CSAI–2 was administered immediately prior to Experiment 1 and Experiment 2.

In Experiment 1, performance of the three groups improved over trials in Experiment 1 in terms of accuracy, consistency, and variability. The external focus strategy group demonstrated a longer QED than the internal focus strategy group and the control group. However, there was no performance difference between the three strategy groups.

In Experiment 2, the external focus strategy and internal focus strategy groups demonstrated better dart performance in terms of less variability than the non-strategy (control) group with competition and non-competition condition combined. The external focus strategy group demonstrated a significantly longer QED than the internal focus strategy group and the control group under the non competition condition as well as under the competition condition. However, there was no QED difference between the internal focus strategy group and the control group under the competition and non-competition conditions. Performance of the three strategy groups improved over trials in Experiment 2 in terms of accuracy and variability.

Conclusions

The following conclusions are made based on the findings in this study:

1. For practical purposes, the use of an external focus strategy or an internal focus strategy is equally beneficial to the performance of the underhand dart tossing task.

2. The performance advantage of an external focus strategy over an internal focus strategy is not confirmed.

3. A particular attentional strategy can significantly influence a performer's gaze behavior, as measured by QED, which is supposed to be critical period of cognitive programming required to aim to a target successfully. The external focus strategy increased QED time.

4. An increase in QED does not always guarantee better performance in self-paced, far target aiming tasks. Although an external focus strategy group had significantly longer QED than an internal focus strategy group, performance of these two groups did not differ.

5. A moderate increase in competitive anxiety (somatic and cognitive) is not facilitative or detrimental to performance. Performance under the higher competitive anxiety condition leading to moderately higher cognitive and somatic anxiety levels was compatible to that under the lower competitive anxiety condition.

6. The influence of attentional strategies on components of anxiety is not observable. The CSAI–2 profiles of the three groups were comparable.

7. Moderately higher competitive anxiety enhances the positive influence of an external focus strategy on QED. The external focus strategy group under the competition condition demonstrated longer QED compared with the other groups.

8. The viability of processing efficiency theory to explain the data is supported. The processing efficiency theory, which describes the anxiety performance relationship, also provides a reasonable explanation for an increase in QED under higher anxiety conditions.

Implication For Future Study

1. Investigated was the usefulness of QED as an indicator that represents allocation of visual attention as well as an index that distinguishes the use of particular attentional strategies. Researchers in sport psychology as well as in other related science fields are attempting to determine psychophysiological measures that underlie better performance. As Vickers suggested, QED may be a useful index to show internal cognitive processing while performing various self-paced tasks. However, research examining the direct relationship between QED and performance is rare due to difficulty of relating QED to performance outcome on each trial. This kind of study is necessary to establish a more concrete relationship between QED and motor skill performance.

2. Although a few researchers have investigated QED and performance with self-paced motor tasks, the optimal duration is still not clear. Future researchers should attempt to determine an appropriate scientific method to address this issue. One of the possible ways could be by placing various time limits for performing a task as Frehlich (1997) did, or assigning various task difficulty levels to subjects while recording QED.

3. Eysenck's (1996) processing efficiency theory is promising to explain the mechanism of QED change in relation to anxiety level. In the theory, Eysenck and Calvo (1992) suggested that higher state anxiety would cause increase in effort to improve performance, and this effort should be greater for individuals with higher trait anxiety. In the present study, only state anxiety was examined. Therefore, further studies that involve trait anxiety measurements are needed for more valid application of this theory.

4. Though the catastrophe model has been considered very complicated to understand and difficult to be applied in experimental research with real-world tasks, it is one of the widely accepted theories to explain the intricate relationship between anxiety and sport performance. In a more stringent investigation of this theory, future research should include physiological arousal measurements as well as the time to event paradigm.

5. In the present study, two rival learning strategies, the external focus strategy and the internal focus strategy, were compared. Which of two strategies is superior to facilitate the learning of a novel skill was not confirmed. Learners may need more time to realize a more observable benefit from one or both of these strategies. Therefore, an increased number of trials as well as a larger sample size are recommended order to increase the probability that such effects will occur, if indeed they are present.

6. Among various cognitive strategies examined so far, Singer's (1984) Five Step Strategy has been established as one of more effective ones. However, it has been rarely studied with QED under a competition condition except for one study by Radlo (1997). It would be interesting to investigate the effectiveness of this general learning strategy in relation to physiological arousal, competitive anxiety, QED, and performance.

In summary, this study attempted to investigate QED, attentional strategies, and competitive anxiety together with regard to underhand dart throwing performance. Determining the relationship of these variables is a challenge. Further research is needed in this area, with more elaborate methodology, in order to gain greater insight into the issues raised in this study.

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APPENDIX A
COMPETITIVE STATE ANXIETY INVENTORY - 2 (CSAI-2)

Dart Task Self-Evaluation Questionnaire - Trial # _____ Sub #:_____

Directions: A number of statements which athletes have used to describe their feelings before competition are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate *how you felt during the dart test*. There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer that describes your feelings *as if you are doing dart now.*

	Not At All	Somewhat	Moderately So	Very Much So
1. I am concerned about this competition	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

2. I feel nervous.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

3. I feel at ease.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

4. I have self-doubts.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

5. I feel jittery.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

6. I feel comfortable. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

7. I am concerned that I may not do as well in this competition as I could. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

8. My body feels tense. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

9. I feel self-confident. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

10. I am concerned about losing. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

11. I feel tense in my stomach. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

12. I feel secure. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

13. I am concerned about choking under

pressure.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

14. My body feels relaxed.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

15. I'm confident that I can meet the challenge.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

16. I'm concerned about performing poorly	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

17. My heart is racing.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

18. I'm confident about performing well.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

19. I'm worried about reaching my goal.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

20. I feel my stomach sinking.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

21. I feel mentally relaxed. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

22. I'm concerned that others will be disappointed with my performance. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

23. My hands are clammy. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

24. I'm confident because I mentally picture myself reaching my goal. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

25. I'm concerned that I won't be able to concentrate. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

26. My body feels tight. 1 2 3 4

Is this symptom facilitative or debilitative to your subsequent performance?
Very debilitative **Very Facilitative**
-3 -2 -1 0 1 2 3

27. I'm confident of coming through under pressure.	1	2	3	4

Is this symptom facilitative or debilitative to your subsequent performance?

Very debilitative **Very Facilitative**

-3 -2 -1 0 1 2 3

APPENDIX B
INFORMED CONSENT FORM

University of Florida
Department of Exercise and Sport Science
Informed Consent Form

Project Title: The Effect of Locus of Attentional Focus and Competitive Conditions on Optimal Visual Orientation Time to a Target and Achievement in a Dart Tossing Skill.

Principal Investigators: Ko, Wisug., Graduate Student; Robert N. Singer, Ph.D., Professor and Chair, Department of exercise and Sport Sciences, FLG 101, Phone: (352) 392-0584.

This is to certify that I________________________, hereby agree to participate as a volunteer in this scientific investigation as part of an authorized research program at the University of Florida, under the supervision of Robert N. Singer.

Purpose of Testing Procedures

The purpose of this study is to investigate the effects of the number of practice trials on dart-throw performance. Participants will be tested in two separate test sessions. Upon arrival at the test site, participants will get instructions for the task. They will then complete 64 trials of underhand dart throw on a target board. In the second session, the participants will finish another 32 trials. The experiment will take approximately 30 minutes for the first session and 15 minutes for the second session.

General Information

1. I understand that the principal investigator will answer any of my questions about the research project and my right as a volunteer subject.
2. I understand that there is minimal risk to my health and well being. In addition, there are no direct benefits to me for participating.
3. I understand that I am free to withdraw my consent and to terminate my participation at any time.
4. I understand that if there are questions I do not wish to answer, I do not have to answer.
5. I understand that my data and answers to any questions will remain completely confidential to the extent provided by law. My identity will be withheld from data files, sheet, and analyses because a number coding system will be used. Only grouped data will be reported in any future publication.
6. Questions or concerns about my rights as a participant can be directed to the UFIRB office, Box 112250, University of Florida, (352) 392-0433.

I have read and/or discussed the procedure described above and I understand the procedure. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Signature of Participant ______________________ Date ___/___/___ Age _____
Signature of Witness ______________________ Date ___/___/___ Age _____

I have defined and fully explained this study to the above named subject:
Signature of Principal Investigator ____________________ Date ___/___/___

APPENDIX C
INSTRUCTIONS FOR EACH GROUP

Instructions for the External Focus Strategy Group

When skilled athletes in such sports as golf or bowling are asked what they think about during execution, they usually answer that they do not think much about what they are doing. Instead, they try to concentrate on the most important cue, thought, or feeling for them related to successful performance, immediately before initiating the movement act. Everything then appears to become automatic. The desired movements and the outcome seem to occur without conscious control. Simply said, "things just seem to happen." Skilled athletes generally use an external focus strategy while they perform. They don't focus on themselves or what they are doing. They generate an image of what they intend to do as well as positive feelings, and then focus on a cue. In dart competition, for example, the best dart throwers don't want to be aware of the numerous details of the mechanical aspects of toss or of their body movements while they execute. Rather, they focus on one most important external source of information (the center of the dart board: the bull's eye). Such concentration helps to block out distractive and negative thoughts. Thinking about the movement itself during performance may be detrimental. The idea is to have full concentration on one external cue following the readiness ritual, and to remain focused during the act. This is what great basketball foul-shooters do. The same is true with golfers, pistol shooters, archers, and bowlers.

To improve your underhand dart throw performance, you should try to use the same strategy that experts use. When you perform the dart throw, try not to think about

what you are doing; don't think about unnecessary and specific details such as the movement of your arm, the length of the back swing, the position of your legs, your muscle tension, and the way your fingers hold the dart. Get into comfortable position, think about making a great toss, and then focus on the bull's eye. When everything feels right, toss the dart with continual focus on the bull's eye.

Use the following guidelines for the external focus strategy each time you are ready to toss the dart:

- Focus on the center of the dart board (the bull's eye).
- While you focus on the center of the dart board, expand the center, making it as large as possible.
- Toss the dart when you feel everything is right.

In summary, try to focus on the bull's eye prior to and during each toss. This concentration is crucial for the successful execution of the act each time. Do not focus on what you are doing. Let the movement flow. Trust yourself, relax, and perform as if in a state of automaticity. Remember, if you are able to follow these specific instructions, you should perform well.

Once again, the external focus strategy involves:

Not thinking of anything about the action itself or the possible outcome.

Maintaining your visual focus on the target (the bull's eye) to block out all other unnecessary and distracting thoughts.

Preplaning your action and then just doing it.

Trusting your ability to score well.

Do you have any questions about this strategy?

Instructions for the Internal Focus Strategy Group

When you perform sport skills such as, running, swimming, serving a ball in tennis, and putting a golf ball, you can feel the movements of your body. For example, when you putt a golf ball into the hole, you can feel the movements of your head, wrist, arms, waist, and legs. The ability to "feel" your movement during the learning and performing of a sport skill should help you achieve. Information about what the body parts are doing is provided by specific receptors which are located in the muscles, tendons, joints, and on the surface of the skin. You can use this information to help you control your body during performing sport skills. That is why some golf coaches say "feel your body", or "feel the movement" when they teach novices.

When performing an aiming skill, such as dart throwing or shooting a basketball, you are able to use this sense of feel information to help to improve your performance. This process is called on internal focus strategy. It is associated with paying attention to what you are doing during movement execution, and with using self-cues to control your movement. The following are guidelines for applying the internal focus strategy when you are ready for each dart toss:

- Focus on your body sensations, and try to feel the movement of your arm holding a dart.
- Feel the tension of muscles in your legs.
- Feel the weight of the dart in your hand
- Feel the movement of your arm holding a dart during the backswing, and the bend in the elbow.
- Feel the dart as it leaves your finger tips.

Be aware of the movement of your body parts as you move the dart. Feel the position of your arm from the initiation of the movement to completion, and the rhythm that you generate. When performing the dart toss, direct your attention to your body, such as the parts of your tossing arm each time you throw the dart, the length of the back swing, and the release point.

In summary, conscious attention to these cues will allow you to control your movements accurately and smoothly. Remember, paying attention to all of the sensations related to specific movements of your body during the execution should result in better performance.

Once again the internal focus strategy involves:

Paying attention to what you are doing while you are executing the underhand dart toss.

Feeling the sensation in your body as you initiate and complete the movement.

Being aware of all the parts of your body involved in the movement.

Do you have any questions about the strategy?

Instructions for the Control Group

One of England's oldest sports, the game called darts is played by throwing darts at a circular, numbered board. The game is most popular in English pubs, or public houses, and the similar American neighborhood taverns as a friendly competition between individuals or teams.

The dart board is a circle that is 18 inches (45.72 centimeters) in diameter. It is mounted on a wall so that its center is about 5 feet 8 inches (172.72 centimeters) above the floor. The board is normally made of cork, bristle, elm, or some other material that the darts can easily stick into. The board is divided like a sliced cake or pie into 20 sectors. The sectors are separated by thin wires or other dividers. Each sector is marked with a point value ranging from 1 to 20, but the numbers are not in consecutive order. A narrow outer ring, which runs through all sectors, doubles the value of the sector for all darts thrown into it. Closer to the center is another narrow ring. This one triples the value of darts in it. In the center of the board are an inner bull's-eye, with a value of 50 points, and a ring surrounding it, also called a bull's-eye, worth 25 points. The darts themselves are about 6 inches (15 centimeters) long. They are weighted and are feathered much like an arrow at one end and have a needlelike point at the other. Each player takes turns throwing three darts from a distance of 8 feet, in the United States, or 9 feet, in Great Britain (2.44 or 2.74 meters).

In the standard game, the scoring proceeds backward from 301 to zero. Each player must get a dart in the narrow outer ring to begin scoring. This and all subsequent scores are subtracted from 301. To win, a player must reach exactly zero with a final shot in the narrow outer ring again. If, for instance, only 20 points are needed to reach

zero, the player would have to aim for and hit the 10 sector in the double ring. If the throw reduces the score to only one point or takes the total below zero, the score reverts to the total of the previous turn.

In some places different kinds of dart boards are used. For example, certain Yorkshire and Irish boards have a single bull (bull is short for bull's-eye) and no triple rings. Outside of tournament play, the rules of the game, too, may vary.

The game of darts may go back as far as the 12th century. It began as butts, an indoor form of archery, with the butts, or rounded ends, of barrels as targets. It had become a tournament pastime by the 16th century. The Pilgrim Fathers who came to North America aboard the Mayflower in 1620 played darts on the journey. In Britain today there are about 7,000 dart clubs in the National Darts Association. Other groups that oversee dart-playing contests are the British Darts Organization and the Scottish Darts Association. In addition to a million registered players, there are more than 5 million players who are not affiliated with clubs.

The American Dart Association was formed in 1933. The United States Darting Association, which was organized in 1969, conducts an annual national open tournament. The British Darts Organization (BDO) was formed in 1973 by Olly Croft, and coordinated the strengths of the various county associations and the development of various county championships, with the organization of international events following soon after. In 1976 the BDO was a major force in setting up the World Darts Federation (WDF), which was formed by representatives from 15 countries to govern and promote the sport of darts on an international basis.

APPENDIX D
PRE-TEST QUESTIONNAIRE

Subject Number: ________________ Date: ___________

Gender: M_____ F_____ Age: __________

(1) Have you played darts? Yes_____ No_____

(2) If you have played darts, have you played on more than five occasions during the past 10 years?

Yes_____ No_____

APPENDIX E
POST-TEST QUESTIONNAIRE

Subject Number:_______________ Date:________________

(1) Did you attempt to use any particular strategy that you can identify to perform well during each test session? (If you say No for this question, ignore questions 2 & 3, please!)

Yes_____ No_____

(2) If so, what kind of strategy or strategies did you use? Please describe it or them.

(3) What percentage of attempts do you think you used the above strategy or strategies? Mark one of 10 scales (from 0 % to 100 %).

Session 1

0-----10-----20-----30-----40-----50-----60-----70-----80-----90-----100 %

Session 2

0-----10-----20-----30-----40-----50-----60-----70-----80-----90-----100 %

APPENDIX F
DESCRIPTIVE STATISTICS

Descriptive Statistics for Dart Performance in Experiment 1

	Strategy	Trial	M	SD
MRE	Control	1	6.99	2.12
		2	6.17	1.77
		3	5.05	1.81
		4	5.55	1.82
		5	5.46	1.42
		6	5.25	1.45
		7	5.07	2.02
		8	4.56	1.31
		Total	5.51	1.83
	External	1	5.32	1.60
		2	4.97	1.40
		3	4.62	1.43
		4	4.77	1.90
		5	4.27	1.14
		6	4.11	1.09
		7	3.89	0.97
		8	4.13	1.20
		Total	4.51	1.41
	Internal	1	5.88	1.40
		2	5.73	0.97
		3	5.49	1.56
		4	4.46	1.07
		5	4.56	0.92
		6	4.04	0.87
		7	4.42	0.93
		8	4.45	0.95
		Total	4.88	1.26
	Total	1	6.06	1.83
		2	5.62	1.47
		3	5.05	1.61

		4	4.93	1.67
		5	4.77	1.26
		6	4.47	1.26
		7	4.46	1.45
		8	4.38	1.15
		Total	4.97	1.57
SRE	Control	1	3.75	2.24
		2	3.02	1.47
		3	2.25	1.42
		4	2.85	1.35
		5	3.03	1.43
		6	2.60	1.72
		7	2.24	1.83
		8	1.74	0.93
		Total	2.68	1.65
	External	1	2.74	1.61
		2	2.25	1.10
		3	1.74	0.81
		4	1.94	0.91
		5	1.90	1.41
		6	1.49	0.90
		7	1.60	0.72
		8	1.69	1.44
		Total	1.92	1.18
	Internal	1	3.44	2.30
		2	2.86	1.65
		3	2.19	1.40
		4	2.12	0.84
		5	2.04	0.74
		6	1.44	0.74
		7	2.12	1.04
		8	1.78	0.67
		Total	2.25	1.38
	Total	1	3.31	2.07
		2	2.71	1.43
		3	2.06	1.23
		4	2.30	1.11
		5	2.32	1.31
		6	1.84	1.29

		7	1.99	1.28
		8	1.74	1.04
		Total	2.28	1.45
BVE	Control	1	6.58	2.21
		2	6.15	1.81
		3	5.14	1.83
		4	5.45	1.96
		5	5.20	1.73
		6	5.10	1.48
		7	4.98	2.20
		8	4.70	1.55
		Total	5.41	1.90
	External	1	4.98	1.49
		2	4.98	1.65
		3	4.77	1.46
		4	4.90	1.90
		5	4.25	1.35
		6	4.23	1.16
		7	4.01	1.22
		8	4.02	1.13
		Total	4.52	1.45
	Internal	1	5.36	1.47
		2	5.48	1.51
		3	5.48	2.00
		4	4.44	1.44
		5	4.81	1.30
		6	4.08	0.77
		7	4.46	1.22
		8	4.91	1.34
		Total	4.88	1.46
	Total	1	5.64	1.85
		2	5.54	1.69
		3	5.13	1.76
		4	4.93	1.79
		5	4.75	1.49
		6	4.47	1.23
		7	4.48	1.63
		8	4.54	1.37
		Total	4.94	1.65

Descriptive Statistics for Dart Performance in Experiment 2

	Strategy	Compete	Trial	M	SD
MRE	Control	C	1.00	5.62	1.84
			2.00	5.07	1.36
			3.00	4.77	1.36
			4.00	5.05	1.29
			Total	5.13	1.43
		NC	1.00	5.46	1.38
			2.00	4.58	1.23
			3.00	4.28	1.21
			4.00	4.93	1.71
			Total	4.81	1.39
		Total	1.00	5.54	1.57
			2.00	4.83	1.27
			3.00	4.52	1.27
			4.00	4.99	1.45
			Total	4.97	1.41
	External	C	1.00	4.13	1.13
			2.00	4.12	1.27
			3.00	4.09	1.26
			4.00	3.64	1.05
			Total	3.99	1.14
		NC	1.00	4.21	1.64
			2.00	4.12	0.94
			3.00	3.77	0.91
			4.00	4.15	0.94
			Total	4.06	1.10
		Total	1.00	4.17	1.36
			2.00	4.12	1.07
			3.00	3.93	1.07
			4.00	3.90	1.00
			Total	4.03	1.11
	Internal	C	1.00	4.91	0.93
			2.00	4.34	0.80
			3.00	3.56	0.50
			4.00	3.83	1.02

			Total	4.16	0.95
		NC	1.00	4.21	0.63
			2.00	4.56	0.99
			3.00	4.09	1.20
			4.00	3.77	0.50
			Total	4.16	0.87
		Total	1.00	4.56	0.85
			2.00	4.45	0.87
			3.00	3.83	0.92
			4.00	3.80	0.77
			Total	4.16	0.90
	Total	C	1.00	4.88	1.43
			2.00	4.51	1.19
			3.00	4.14	1.17
			4.00	4.17	1.24
			Total	4.43	1.28
		NC	1.00	4.62	1.37
			2.00	4.42	1.03
			3.00	4.05	1.08
			4.00	4.28	1.21
			Total	4.34	1.18
		Total	1.00	4.75	1.39
			2.00	4.46	1.10
			3.00	4.09	1.11
			4.00	4.23	1.21
			Total	4.38	1.22
SRE	Control	C	1.00	2.48	1.21
			2.00	2.67	1.27
			3.00	2.90	1.75
			4.00	2.40	1.44
			Total	2.61	1.37
		NC	1.00	2.09	1.12
			2.00	1.92	1.38
			3.00	1.61	0.47
			4.00	2.73	1.02
			Total	2.09	1.08
		Total	1.00	2.29	1.14
			2.00	2.30	1.33
			3.00	2.25	1.40

		4.00	2.56	1.22
		Total	2.35	1.25
External	C	1.00	1.35	0.64
		2.00	1.32	0.80
		3.00	1.30	0.87
		4.00	1.87	1.05
		Total	1.46	0.84
	NC	1.00	2.19	1.50
		2.00	2.44	0.85
		3.00	1.14	0.83
		4.00	1.33	0.54
		Total	1.77	1.09
	Total	1.00	1.77	1.19
		2.00	1.88	0.99
		3.00	1.22	0.82
		4.00	1.60	0.85
		Total	1.62	0.98
Internal	C	1.00	2.06	1.52
		2.00	1.29	0.64
		3.00	1.51	0.47
		4.00	1.03	0.50
		Total	1.47	0.93
	NC	1.00	1.67	0.58
		2.00	1.74	1.23
		3.00	2.68	1.50
		4.00	1.61	0.44
		Total	1.93	1.07
	Total	1.00	1.87	1.13
		2.00	1.52	0.97
		3.00	2.10	1.23
		4.00	1.32	0.55
		Total	1.70	1.02
Total	C	1.00	1.97	1.22
		2.00	1.76	1.11
		3.00	1.91	1.32
		4.00	1.77	1.17
		Total	1.85	1.19
	NC	1.00	1.98	1.10
		2.00	2.03	1.16

			3.00	1.81	1.18
			4.00	1.89	0.92
			Total	1.93	1.07
		Total	1.00	1.97	1.15
			2.00	1.90	1.13
			3.00	1.86	1.23
			4.00	1.83	1.04
			Total	1.89	1.13
BVE	Control	C	1.00	5.70	1.77
			2.00	4.73	1.71
			3.00	4.35	0.87
			4.00	5.10	1.30
			Total	4.97	1.47
		NC	1.00	5.98	1.35
			2.00	4.79	1.43
			3.00	4.47	1.66
			4.00	4.95	1.79
			Total	5.05	1.59
		Total	1.00	5.84	1.52
			2.00	4.76	1.52
			3.00	4.41	1.28
			4.00	5.03	1.51
			Total	5.01	1.51
	External	C	1.00	4.26	1.34
			2.00	4.29	1.48
			3.00	4.38	1.08
			4.00	3.62	0.93
			Total	4.14	1.19
		NC	1.00	3.93	1.24
			2.00	3.86	0.89
			3.00	3.90	1.05
			4.00	4.41	1.00
			Total	4.03	1.02
		Total	1.00	4.10	1.25
			2.00	4.07	1.19
			3.00	4.14	1.05
			4.00	4.02	1.02
			Total	4.08	1.10
	Internal	C	1.00	5.13	0.77

		2.00	4.63	1.10
		3.00	3.44	0.54
		4.00	4.04	1.32
		Total	4.31	1.13
	NC	1.00	4.24	0.78
		2.00	4.52	0.93
		3.00	3.57	1.20
		4.00	3.77	0.59
		Total	4.03	0.93
	Total	1.00	4.69	0.88
		2.00	4.58	0.98
		3.00	3.51	0.90
		4.00	3.90	0.99
		Total	4.17	1.04
Total	C	1.00	5.03	1.42
		2.00	4.55	1.39
		3.00	4.06	0.93
		4.00	4.25	1.30
		Total	4.47	1.31
	NC	1.00	4.72	1.43
		2.00	4.39	1.13
		3.00	3.98	1.32
		4.00	4.38	1.27
		Total	4.37	1.29
	Total	1.00	4.87	1.42
		2.00	4.47	1.25
		3.00	4.02	1.13
		4.00	4.31	1.27
		Total	4.42	1.30

Descriptive Statistics for CSAI-2

	Group	Trial	M	SD
COGNITIVE	External Compete	1.00	11.00	1.91
		2.00	13.00	6.73
		Total	12.00	4.87
	External Noncompete	1.00	13.00	1.83
		2.00	11.00	1.00
		Total	12.00	1.75
	Internal Compete	1.00	13.14	3.58
		2.00	16.43	6.13
		Total	14.79	5.12
	Internal Noncompete	1.00	15.29	3.09
		2.00	14.86	4.45
		Total	15.07	3.69
	Control Compete	1.00	15.43	4.72
		2.00	16.29	4.54
		Total	15.86	4.47
	Control Noncompete	1.00	15.14	4.30
		2.00	12.29	3.45
		Total	13.71	4.03
	Total	1.00	13.83	3.59
		2.00	13.98	4.92
		Total	13.90	4.28
SOMATIC	External Compete	1.00	12.14	1.46
		2.00	15.00	5.83
		Total	13.57	4.35
	External Noncompete	1.00	12.57	2.07
		2.00	11.43	1.40
		Total	12.00	1.80
	Internal Compete	1.00	13.57	2.44
		2.00	17.57	5.68
		Total	15.57	4.69
	Internal Noncompete	1.00	15.71	3.30
		2.00	14.86	3.53
		Total	15.29	3.31
	Control Compete	1.00	15.00	4.04

		2.00	15.14	3.39
		Total	15.07	3.58
	Control Noncompete	1.00	14.86	3.63
		2.00	12.71	3.25
		Total	13.79	3.49
	Total	1.00	13.98	3.08
		2.00	14.45	4.35
		Total	14.21	3.75
SELF-CON	External Compete	1.00	25.71	4.35
		2.00	23.00	5.80
		Total	24.36	5.12
	External Noncompete	1.00	22.71	7.02
		2.00	22.71	8.44
		Total	22.71	7.46
	Internal Compete	1.00	22.43	6.45
		2.00	20.57	6.95
		Total	21.50	6.51
	Internal Noncompete	1.00	21.00	4.24
		2.00	21.57	3.69
		Total	21.29	3.83
	Control Compete	1.00	24.29	1.98
		2.00	22.57	4.04
		Total	23.43	3.18
	Control Noncompete	1.00	23.14	5.93
		2.00	27.00	7.87
		Total	25.07	6.99
	Total	1.00	23.21	5.16
		2.00	22.90	6.32
		Total	23.06	5.74
DIRECTION	External Compete	1.00	31.29	26.52
		2.00	36.00	18.63
		Total	33.64	22.15
	External Noncompete	1.00	25.00	18.25
		2.00	26.71	21.13
		Total	25.86	18.99
	Internal Compete	1.00	20.29	25.79
		2.00	11.71	37.34
		Total	16.00	31.15
	Internal Noncompete	1.00	9.71	17.03

	2.00	6.29	18.45
	Total	8.00	17.15
Control Compete	1.00	20.86	9.99
	2.00	27.57	19.00
	Total	24.21	14.99
Control Noncompete	1.00	18.00	19.29
	2.00	19.00	17.63
	Total	18.50	17.76
Total	1.00	20.86	20.11
	2.00	21.21	23.92
	Total	21.04	21.96

BIOGRAPHICAL SKETCH

Wisug Ko was born on August 9, 1967, in Seoul, South Korea. He graduated from Yoido High School in 1986. In the spring of that year, he entered Yonsei University, Seoul, and graduated with a Bachelor of Arts degree in physical education in the spring of 1990. After 2 years of military service, he entered the graduate program of the College of Health, Physical Education, and Recreation at Indiana University, Bloomington, Indiana, and earned his Master of Arts degree in motor behavior in 1995. In the same year, Wisug entered the doctoral program of the College of Health and Human Performance at the University of Florida, specializing in motor behavior and sport psychology. He earned his Doctor of Philosophy degree in the fall of 2000. Prior to completing his studies at the University of Florida, he was employed as a lecturer in the Department of Physical Education at Yonsei University, where he taught undergraduate and graduate classes in motor behavior and sport psychology. Wisug is currently employed as a lecturer at Yonsei University and Kyungkee University.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert N. Singer, Chair
Professor of Exercise and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Milledge Murphey
Associate Professor of Exercise and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Christopher M. Janelle
Assistant Professor of Exercise and Sport Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ira Fischler
Professor of Psychology

This dissertation was submitted to the Graduate Faculty of the College of Health and Human Performance and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May 2001

Dean, College of Health and Human Performance

Dean, Graduate School